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THE FEBRUARY SCIENTIFIC MONTHLY

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THE SCIENTIFIC MONTHLY

FEBRUARY, 1936

A GENETICIST STUDIES LEUKEMIA

By Dr. E. C. MacDOWELL

DEPARTMENT OF GENETICS, CARNEGIE INSTITUTION OF WASHINGTON

ONE of the happiest of human experiences is to make a desirable plan and then be able to carry it out. Such has been my experience during the last seven years in studying leukemia. And this is true in spite of the fact that this study places leukemia among the most dreaded of all diseases. For the belief has been sustained throughout that this work was leading towards a better understanding of normal life processes as well as of a disease. The opportunity for such a rich experience depended upon the discovery of leukemia in one of the pure-bred strains of mice in our colony, and upon the greatly appreciated support of Columbia University and Carnegie Institution of Washington, backed by the Carnegie Corporation.

In the technical publications that record these results, broad interpretations are lacking. For interpretations belong to the alluring region just beyond the borders of demonstrable fact. Yet it is this region of interpretation that often gives unity and significance to the separate bits of knowledge; here the investigator spends much of his time; into this region his course must be charted; here lies his keenest interest. With the hope that that which most interests the investigator may interest the reader, I shall deliberately emphasize interpretation. But it must be clearly understood that interpretations are not conclusions, but rather beacons lighting the way.

LEUKEMIA AS A FAILURE IN GROWTH CONTROL

Growth, as one of the primary characteristics of living matter, has been studied from many points of view. Usually interest is centered on the progressive phase, but the control or termination of growth may have great significance.

What stops growth? Insufficient food stops a baby's growth; a defective endocrine gland may produce a dwarf; and a certain set of genes may normally stop growth of a mammal before it is larger than your thumb, while another set of genes permits growth to continue until the size of an elephant is reached. But these results consider the individual as though it were homogeneous, as though a sack being filled with grain; they give no understanding of the mechanism that controls the growth of each kind of tissue in forming the harmonious whole, with enough and not too much bone and muscle and connective tissue and skin. It is to this phase of growth that my question especially applies. What stops growth of a given tissue?

As long as the differential control of tissue growth operates successfully, it may seem axiomatic, but failures in the operation of this mechanism immediately raise the question of its nature and at the same time offer a possible approach to its study. For normal processes can frequently be analyzed by their abnormal deviations. Failures in the normal con-

FIG. 1. DISSECTION OF LEUKEMIC MOUSE

SHOWING ENLARGEMENT OF CERVICAL, AXILLARY, INGUINAL, MESENTERIC, POPLITEAL AND LUMBAR LYMPH NODES; GREATLY ENLARGED SPLEEN TURNED OUTWARDS; RIBS ENTIRELY REMOVED, SHOWING TUMOROUS ENLARGEMENT OF THYMUS SURROUNDING HEART, WHICH IS NEARLY CONCEALED.

trol of tissue growth lead to tumors. A part of some tissue escapes from its normal control and grows wildly without relation to the requirements of the individual; the useless masses of this tissue interfere with normal functions and often interrupt some vital process and cause death. All kinds of tissue may show tumorous growth and many kinds of tumors are named according to the tissue and point of origin.

Some normal tissues, instead of forming compact masses or sheets, consist of independent cells that migrate from place to place. Among such tissues are the various types of white blood cells. To recognize tumorous growth of such cells is not easy, for, besides their freedom of migration, their normal functions involve great variations in their numbers. However, certain white cells sometimes increase beyond all purpose; they multiply at a terrific rate wherever they are and permeate any or all other tissues of the body. From the enormous numbers of white cells in the blood, the name leukemia was given. *Leukemia* means white blood, as *anemia* means without blood. As used herein, the term leukemia applies to a group of conditions resulting from the wild growth of these white blood cells. Pathologists have recognized a certain similarity between leukemia and the conditions resulting from the wild growth of other tissues, but the nature of this disease remained in doubt until experimental studies with mice gave conclusive evidence that it belongs to the class of tumors.

Leukemia in Man and Mouse

Mouse leukemia shows the very closest likeness to human leukemia. This is true of general characteristics, of variations in manifestation, as well as of the most detailed microscopic features. Indeed microscopic preparations from man and mouse are virtually indistinguishable. Leukemic cells may be distributed in the body with special concentrations in lymph nodes, in spleen, in blood, as well as in kidneys, liver, etc. Again they may be absent from the blood, or they may show very irregular distribution and hugely increase the size of some individual organ or gland. Under these circumstances the final picture of this disease is necessarily different in different cases; but in both man and mouse it is fatal (see Figs. 1–4). Reports of cures are usually due to erroneous diagnosis, temporary remission or to an incompleted chronic history. Surgery is futile; radiation, while destroying large numbers of the leukemic cells and sometimes relieving symptoms, does not destroy all the cells.

Incidence

Newspapers are making the term leukemia increasingly familiar. But it is

still one of the rarer human diseases. Its sporadic occurrence does not suggest a strong genetic control. A similar sporadic occurrence is generally characteristic of mice. But in 1928 it was discovered that a very large proportion of the mice in one of our highly purified strains developed leukemia. Since this was not the case with other strains raised alongside and under the same conditions, it became obvious that the genetic constitution of this strain was responsible for the high incidence of leukemia. The absence of a similar concentration of cases in any human pedigree does not indicate an important difference in the causation of leukemia; this lack of concentration is probably due to the outbreeding characteristic of human matings in contrast to the extreme inbreeding of these mice. Outbreeding leads to the continued dispersal of any given set of genes, while inbreeding holds them together.

Intrinsic *vs.* Extrinsic Influences

But even with the genetic constitution held as uniform as possible in mice, all animals in the leukemic strain did not develop leukemia. In a random sample of over 700 mice, about 10 per cent. failed to show leukemia. Although we had strong reason to believe that these negative mice were genetically the same as the ones that developed leukemia, this was checked by breeding tests which showed that leukemia was as frequent in the offspring of these negative parents as in the offspring of leukemic parents. The 10 per cent. that escaped leukemia would have to thank some rare variation in non-genetic influences. These variations in extrinsic influences must be very subtile, for they may cause differences between litter mates living in the same box.

This interplay of intrinsic and extrinsic influences introduces the prin-

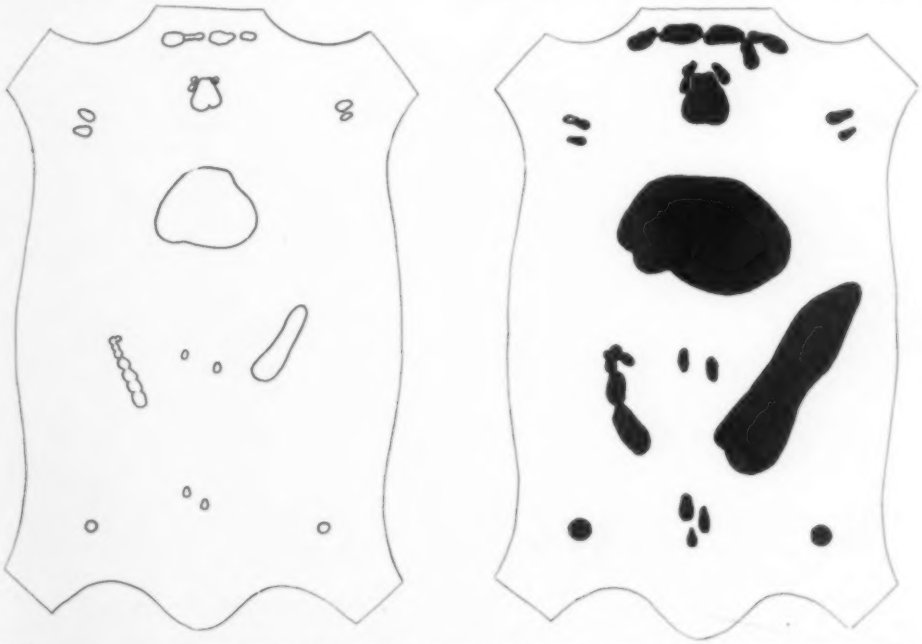


FIG. 2. OUTLINES OF NORMAL ORGANS COMPARED WITH A CASE OF LEUKEMIA WITH MODERATE ENLARGEMENT OF LYMPH NODES AND THYMUS, BUT WITH VERY LARGE LIVER AND SPLEEN.

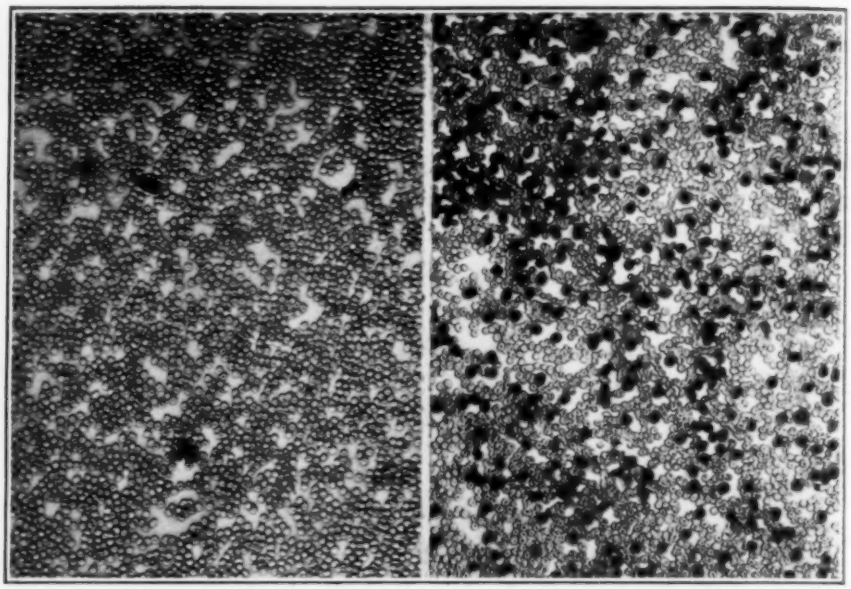


FIG. 3. BLOOD SMEARS OF NORMAL AND LEUKEMIC MICE
SMALL CELLS ARE RED CORPUSCLES, LARGE CELLS ARE WHITE CELLS MADE DARK BY WRIGHT'S STAIN.

cipal theme of this composition—a theme running through a vast array of problems; it leads to knowledge upon which practical procedure depends. How far is our modification of extrinsic conditions helpful and how far useless?

With a natural fondness for classification, we have called some traits genetic and other traits non-genetic. This served well enough in the early days of genetics when such strikingly genetic traits as hair color were studied and so-called non-genetic traits were not studied. But when the whole range of traits was surveyed, it became evident that in reality genetic and non-genetic influences cooperate in the production of every trait; sometimes genetic influences are strong and variations in extrinsic factors relatively weak; sometimes genetic influences are weak and extrinsic factors relatively strong. With these extreme conditions in mind, traits have been called genetic and non-genetic. But probably the majority of traits result from some intermediate balance between genetic and non-genetic influences; in these cases the old classification has no meaning. We can say that all traits are genetic; they differ in the degree of their dependence upon extrinsic influences.

In one strain of mice the genetic factors leading to leukemia are so strong that most of the conditions encountered permit its development, but certain rare variations in extrinsic conditions prevent its development. If we could discover what these rare conditions were and could supply them for all the mice, no case of leukemia would appear. And yet, in some minds there seems to persist an idea that the discovery of genetic control places a trait beyond reach of extrinsic influence! From the present point of view it would be necessary to study every case before concluding that modification by extrinsic factors was ineffective.

In the same colony as the leukemic strain, another strain of mice has been

inbred over the same period of time. This strain is called non-leukemic; but this is a misnomer, for sporadic cases of leukemia have occurred—less than 2 per cent. Such cases would formerly be called non-genetic, but more correctly we should say that the genetic constitution of this strain leads to leukemia only under certain very rare combinations of extrinsic influences.

Hybridization

In an attempt to study the genetic differences between these two strains, fathers from the leukemic strain were crossbred to mothers from the non-leukemic strain. The offspring from such a cross are hybrid; they carry half the total heredity from each strain, but they are all genetically alike. However, only about 45 per cent. of them showed leukemia; that is, the reduction of the total inheritance from the leukemic strain by one half has reduced the incidence of leukemia by about one half. But there was no intermediacy in the leukemic condition when it did appear. Since the non-leukemic mice have the same genetic constitution as the leukemic, the outcome for each mouse must be decided by extrinsic variables. The reduction in genetic factors has increased the importance of extrinsic factors, since now only about half of the situations encountered favor the development of this disease. The weaker the genetic control, the more specialized become the non-genetic requirements.

Here, then, are three groups of mice with three different degrees of leukemic inheritance; within each group there is genetic uniformity, but the relative power of extrinsic influences upon the incidence of leukemia differs for each group (see Fig. 5).

As long as the rôle of extrinsic factors changes with the genetic constitution, the frequency of cases in a second hybrid generation or back-cross can not indicate the number of differential genes.

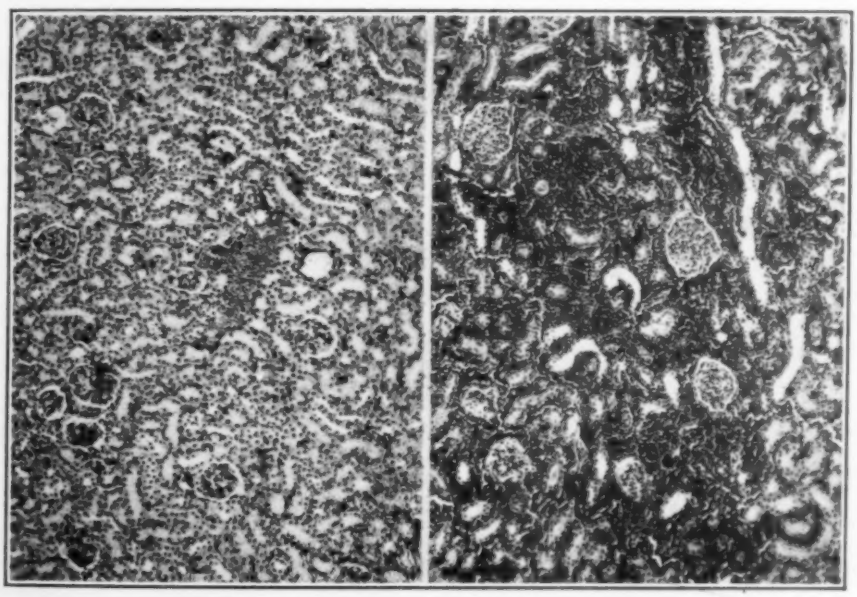


FIG. 4. NORMAL KIDNEY STRUCTURE

IN COMPARISON WITH LEUKEMIC KIDNEY IN WHICH THE WILD GROWTH OF LEUKEMIC CELLS HAS FORCED APART THE KIDNEY TUBULES.

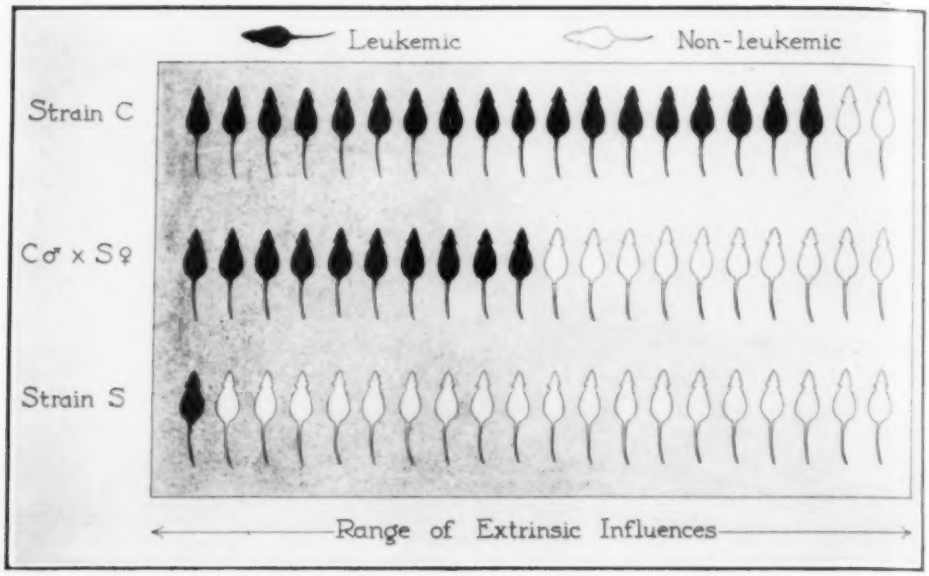


FIG. 5. DIAGRAM; EFFECTIVENESS OF EXTRINSIC INFLUENCES CHANGES WITH GENETIC CONSTITUTION

MICE WITHIN EACH ROW ARE GENETICALLY ALIKE. SHADED BACKGROUND REPRESENTS GRADED SERIES OF EXTRINSIC INFLUENCES.

To determine this, the classification of these individuals by complete breeding tests is necessary. Although at present uninterpretable in terms of genes, it may be noted that the back-cross of hybrid males to females of the non-leukemic strain reduces the incidence of leukemia about one fourth that in the leukemic strain, which again corresponds to the proportion of total heredity from the leukemic strain in this generation as a whole.

GENETIC AND GENIC

Genetics has dealt largely with genes, and the evidence in animals of hereditary transmission by any other means has been so conspicuously absent that the term *genetic*, which refers to heredity, is identical in some minds with *genic*, which refers specifically to genes. But in the cases of leukemia, mammary tumors and longevity, evidence has recently appeared that indicates the existence of some other genetic mechanism than genes carried in chromosomes. This evidence is given by differences in results of an out-cross according as the mother or father transmits the trait. In the out-crosses we have been discussing, leukemia has been transmitted in every case by the father. If now the reciprocal crosses are made, with leukemia transmitted through the mother, the incidence of leukemia in both sons and daughters in every case is markedly higher. Sex-linked inheritance is not involved, since sex-linkage does not give the same results for sons from reciprocal matings as for daughters. Now it happens that the non-leukemic strain transmitted a tendency towards the development of mammary tumors as well as greater longevity than the leukemic strain; and these traits also were more strikingly expressed in both first generation hybrids

and back-cross when transmitted through mothers. Murray and Little have reported the same result for mammary tumors.

The influence of tumors upon length of life and the influence of length of life upon the incidence of tumors have been studied by several investigators, and it seems clear that longevity can not bear any uniform relation to all tumor incidence. Thus leukemia and shorter life are associated in one strain and mammary tumors and longer life in the other. However, there is serious doubt of these correlations having any causal significance. For instance, leukemic offspring from reciprocal crosses show as much difference in length of life as do the non-leukemic offspring; and comparing the different generations, the correlation fails (see Fig. 6).

From our study of spontaneous leukemia four points stand out:

(1) That genetic and non-genetic influences are active.
(2) That the control exerted by non-genetic factors varies as the genetic constitution varies.
(3) That the incidence of leukemia is correlated with the proportion of heredity from the leukemic strain transmitted through fathers.
(4) That some mechanism of hereditary transmission besides chromosomes must be sought.

These statements do not seem to bear upon the subject of growth control; indeed they concern only the occurrence of leukemia without regard to its nature. In introducing the more analytical aspects of this study, I want to take you for a moment far away from leukemia—to a mountain top!

Imagine yourself on the highest peak in Norway. You are in a rope, tied to the guide who is chopping footholds in the upended glacier that crowns the summit. On the left the glacier sweeps suddenly down, on the right, a sharp edge—and beyond, space, reaching out to the bristling peaks and glaciers that ring the horizon. You are watching your footholds very closely. Suddenly you notice something dark just below the surface. It turns out to be the skin and skeleton of a rodent, somewhat larger than a mouse, with a short stubby tail and black and brownish markings.

You ask the guide, "Vaer sa god, hvad er det?" And he replies, "Ach, ja! Det er en lemming."—"Oh, a lemming!" And then you hear the story of the lemmings. How most years they are scarce, but every so often comes a lemming year, when they cover the mountains, stripping the alpine vegetation. They are everywhere; in the wild heights, over the mountain pastures, a serious pest to the dairy farms. A disease breaks out and they die in great numbers. Water supplies become infected and every person in the mountains is liable to catch the dis-

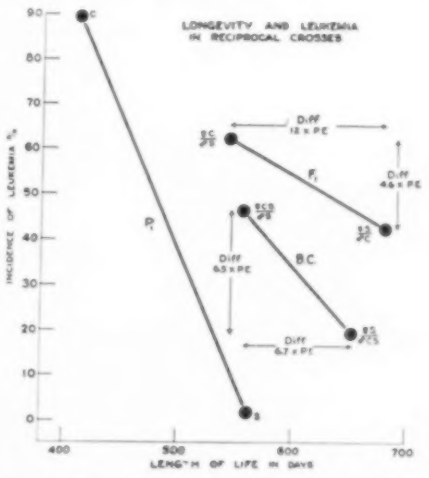


FIG. 6. GRAPH, SHOWING AVERAGES FOR INCIDENCE OF LEUKEMIA (PER CENT.) AND LONGEVITY (IN DAYS) IN THREE GENERATIONS, PARENTAL (P_1), FIRST HYBRID (F_1) AND BACK-CROSS (B. C.). STRAIGHT LINES HAVE NO SIGNIFICANCE BEYOND IDENTIFYING THE PAIR OF POINTS FOR EACH GENERATION. RECIPROCAL MATINGS IN BOTH F_1 AND B. C. SHOW REAL DIFFERENCES BOTH IN INCIDENCE OF LEUKEMIA AND IN LONGEVITY; THE TWO TRAITS ARE NOT CAUSALLY DEPENDENT.

ease, which lays him up for a few days with intestinal symptoms. But even so, the number of lemmings goes on increasing, until the search for food induces great migratory waves. These armies can not go far without coming to a cliff, and the pressure from behind is so great that they march right over the edge! Instead of a water fall, a stream of little animals plunges into the lake or fjord below. And the next year lemmings in Norway are as scarce as usual.

The stage is *now* set within a mouse; the players the leukemic cells; the wild growth of leukemia provides the motivation; and the problem, the analysis of the interrelations of the cells and their surroundings, whereby the leukemic cells escape the inhibitions of their environment, only to cause their own defeat by disorganizing the conditions necessary for their life. The first step in this analysis is to separate the question of the origin of leukemic cells from that of their behavior by using cells that are already leukemic in transplantation experiments.

Transplantation Experiments

If a bit of normal tissue is transplanted from one animal into another, under certain conditions, the transplanted tissue may survive for a long time, but its growth will be as limited as in the animal from which it came. But if the bit of normal tissue is placed in glass, with appropriate nutrient materials, it may exhibit continuous growth. Normal cells have the inherent capacity for continued growth, but within an animal this is restrained by a regulatory control resulting from the organization of the animal as a whole.

Is the continuous growth of leukemic cells due to a change in this regulatory control or in the cells themselves? This question is directly answered by transplanting leukemic cells from a spontaneous case into a normal animal in which the regulatory control of tissue growth is patently intact. In certain animals the transplanted cells will continue their wild growth (see Fig. 7). Since normal cells could not do this, it is clear that leukemic cells are different from normal cells and that a change in the cells, rather than a change in the regulatory mechanism, leads to the disease.

Since leukemic cells will continue their wild growth when transplanted into another mouse, it is possible by successive transfers from mouse to mouse to prolong indefinitely the multiplication of the descendants from the original leukemic cells. Thanks to the consistency and specificity of the results from each series of transfers, it has been demonstrated that leukemia, as stated above, is indeed a disease of new growth. By use of complete serial sections of organs of hosts killed at regular intervals after the inoculation, the leukemic cells were followed microscopically from the time of transplantation to the end. Thus it was found that the leukemic cells invaded the host as though they were protozoan parasites; leukemic cells arose from leukemic cells and only from leukemic cells. Even after passing through hundreds of successive hosts, in the course of many years, the leukemic cells are direct lineal descendants from the spontaneous case in which they originated. The change that rendered certain cells leukemic is inherited by their descendants indefinitely.

If genes were the only means of genetic transmission, we would think that this inherited change involved genes, but reciprocal crosses have shown that some non-chromosomal mechanism is also indicated. Genetic theory insists that the cells of different specialized tissues within an individual carry the same genes, so that some mechanism other than genes must assist in the origin and maintenance of these differences between tissues. It is possible that the same mechanism is involved in all these cases. Until evidence can be secured, the question must remain open: Is the property that distinguishes leukemic from normal cells transmitted from cell generation to cell generation by means of a changed gene or by some other

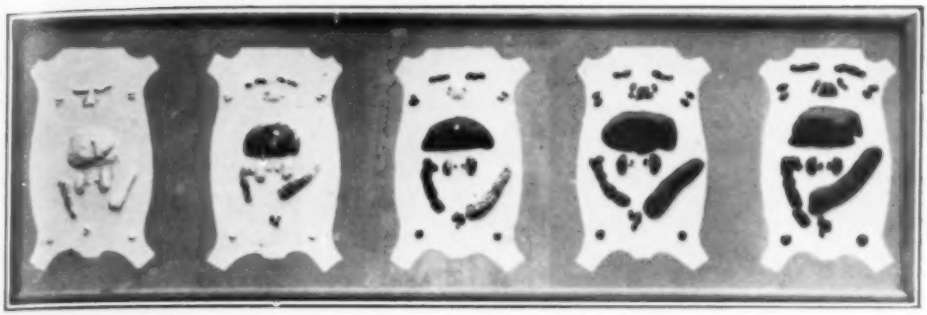


FIG. 7. MODELS OF ORGANS SHOWING DAILY PROGRESS OF LEUKEMIC CELLS AFTER TRANSPLANTATION INTO A NORMAL MOUSE.

mechanism of the cell? This same question applies to all mammalian tumors; it applies to the differences between specialized tissues within an individual; its answer is basic for theories of development and heredity.

EXTRINSIC INFLUENCES UPON LEUKEMIC CELLS

One of the most striking features of the transplantation experiments has been the difference between leukemic cells coming originally from different spontaneous cases. Differences between spontaneous cases have been mentioned, but little could be told of their significance by direct observation; such differences might be due to intrinsic properties of the leukemic cells, or to extrinsic modifications of their behavior. But now when certain leukemic cells reproduce the same picture in every mouse into which they are inoculated, and repeat this transfer after transfer, and when leukemic cells from other spontaneous cases in successive transfers reveal characteristic differences, one is led to believe that differences between spontaneous cases are in some way related to intrinsic differences in their leukemic cells. However, the origin of these intrinsic differences in leukemic cells, within animals of uniform genetic constitution, must depend upon extrinsic factors.

The genetic constitution renders a certain type of white blood cell liable to undergo an inherited change, a change that enables these cells to overcome the normal control of their growth. But we believe the quality of this change depends upon extrinsic factors. When the quality of this change falls below a certain threshold, leukemia does not develop. In this way extrinsic factors may control both the quality of the leukemic cells and the incidence of leukemia.

GENETIC CONTROL OF CELLS' ENVIRONMENT

But this is not the whole story. So far the environment in which the leukemic cells were growing has been held genetically constant, so that the influence of genetic variations has not appeared. But suppose now we apply the method of analysis by deviations to the genetic control of the conditions surrounding the leukemic cells: that is, we will vary the genetic constitution of the host.

Transplanted leukemic cells of a given quality will grow in every mouse of strain A, while in every mouse of strain B their growth is restricted and they finally disappear. A leukemic cell leads to leukemia only in a favorable environment. One environment controls, another does not control leukemic cells. This clear-cut result indicates that this environment is regulated by genetic factors. In one particular case, a detailed genetic analysis was made, which showed that the favorableness supplied by one

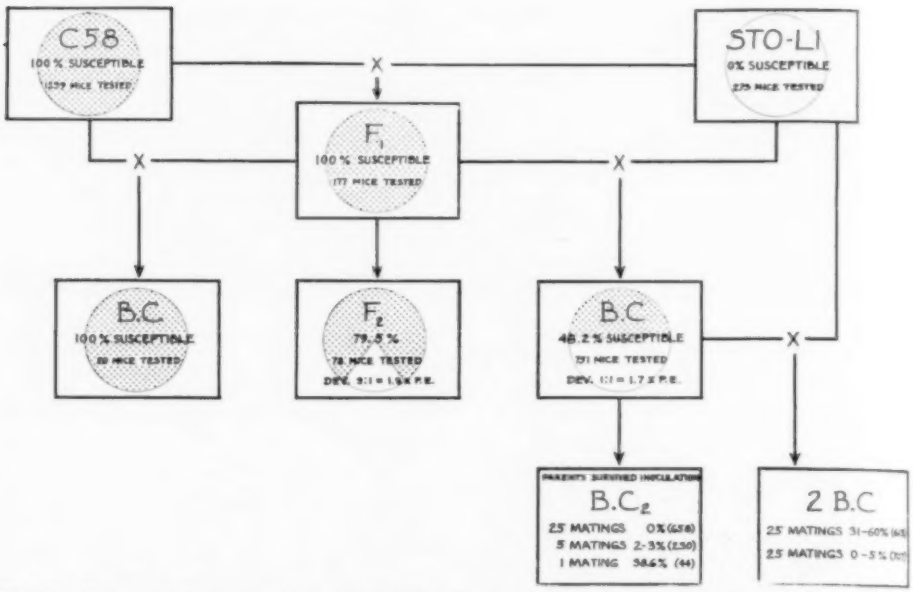


FIG. 8. EVIDENCE THAT ONE GENE DIFFERENTIATES SUSCEPTIBILITY AND RESISTANCE TO ONE PARTICULAR KIND OF TRANSPLANTED LEUKEMIC CELLS. INHERITANCE OF SUSCEPTIBILITY TO INOCULATION, WITH LINE I, AS CONSTITUTED JAN., 1930–MAR., 1931.

strain of hosts in contrast to the unfavorableness supplied by the other strain of hosts depended upon one gene (see Fig. 8).

One gene could turn an unfavorable environment into a favorable one; in terms of the host inoculated with leukemic cells, one gene decided whether it would live or die. Such a simple result in the face of the obviously increasing complexities seems almost like a sudden rainbow of promise. Perhaps after all a powerful gene acting upon the mechanism controlling differential tissue growth may hold the final power. But hope soon dies. It soon appeared that this one gene had such significance for only one particular kind of leukemic cell; that other genes were necessary for other kinds of leukemic cells and that an environment favorable for one leukemic cell might be unfavorable for another. Thus there is no one set of conditions in the body that permits the wild growth of all leukemic cells; the required conditions vary as the cells vary.

EXTRINSIC MODIFICATION OF CELLS' ENVIRONMENT

The ability of the environment provided by the host to control leukemic growth is not determined by genetic constitution alone; here also extrinsic forces may operate. At this point it becomes easier to speak in terms of resistance and susceptibility of the host. A mouse naturally resistant to certain leukemic cells can be rendered susceptible, and a mouse naturally susceptible can be rendered hypersusceptible or resistant. Susceptibility has been induced by Krebs and by Furth, using radiation. Resistance in genetically susceptible animals has been induced by administration of such small numbers of leukemic cells that they did not become established and the mouse survived; then increasingly larger doses of cells were given until eventually the mouse could withstand enormous, massive doses of leukemic cells.

A more rapid induction of resistance followed treatment with certain normal tissues. A single treatment with embryo

skin will enable a susceptible mouse to resist a dose of leukemic cells that would kill every untreated mouse. But this resistance is not due merely to the introduction of normal tissue as such into an abnormal position (abdominal cavity); it depends upon an interaction determined by the genetic constitution of the mouse in relation to that of the normal tissue. If the mouse and the transplanted normal tissue have the same genetic constitution resistance may not be induced. Moreover, in some combinations of constitutions the reaction may be completely reversed, inducing heightened susceptibility instead of resistance. The identical normal tissue that induces resistance when transplanted into hosts of one genetic constitution may strikingly hasten the growth of leukemic cells in hosts of another genetic constitution. This is to say that the reaction of the mouse to one tissue may enable the mouse to resist or to enhance the growth of another tissue.

The different results given by treatments with different normal tissues symbolize the delicacy of the balance in the interaction of tissues. Such interactions may well play a part in the control of tissue growth in the normal process of development. Instead of different transplanted tissues, we have the successive differentiations of specialized tissues which react with the embryo as constituted at the moment and enable it to depress or stimulate a given tissue. With the advent of each new differentiation the reaction system of the animal as a whole is modified, so that its power over the growth of different tissues is constantly changing.

In short, the environment of leukemic cells is a deciding factor in the outcome. Genetic factors may make this environment favorable or unfavorable, but in either case extrinsic factors may reverse the effect of the genetic factors. Treatments with normal embryo skin are among such extrinsic factors, but the effect of normal tissues as extrinsic factors depends in turn upon their genetic constitution. How far this analysis can be utilized in spontaneous cases remains to be seen.

Conclusion

In brief, leukemia depends upon changed cells and their environment. White blood cells are changed by the action of some extrinsic influence upon a genetic tendency to undergo a genetic change. The specific quality of the changed cells depends upon the specific quality of the extrinsic influence. The environment of the changed cells provides a differential control over tissue growth. The change in the cells may or may not enable them to escape this control and to grow wildly. If not, some subsequent change may give the power to overcome this regulatory mechanism. This regulatory mechanism is itself under genetic control and it is also subject to modification by extrinsic influences that may reverse the effect of the specific genetic control. This mechanism is a product of the combined tissues of the body as organized into a whole; its power is built up by countless interactions of tissue upon tissue; these interactions in turn depend upon intrinsic properties as well as extrinsic conditions.

At every point a given intrinsic influence depends in its operation upon the extrinsic influences encountered. An intrinsic condition has arisen as an extrinsic modification of a previous intrinsic condition; an extrinsic influence may itself be intrinsically controlled and extrinsically modified.

Such are the interactions of influences operating in the disease leukemia; such, very broadly, are the interactions of influences in organic development, in the ecological relations of organisms, in the case of the lemmings in Norway, in human behavior. In organic development the extrinsic factors in a given

process are coordinated by antecedent intrinsic factors, while in mental development the extrinsic factors lack this unifying principle. But even so, in mental development as in organic development a given reaction leaves its effect, so that the individual is no longer the same; the next reaction is between the changed individual and the extrinsic factors. The behavior of man is just as much a resultant of intrinsic and extrinsic interactions as the behavior of leukemic cells.

The rôles of intrinsic and extrinsic factors are marvelously interwoven. In the improvement of man we deal mainly with extrinsic influences. But if we are to deal wisely with these, an understanding of intrinsic limitations is essential. From the standpoint of our findings for mouse leukemia, the control of genetic factors has been the outstanding basis of progress. This control has revealed the operation of extrinsic influences on all sides; *their* control may mean the control of leukemia.

Thus a geneticist studies leukemia. But by the side of the geneticist a pathologist has also studied, and a cytologist and a physiologist. And each of these has made important contributions to the account that has been given, but each one also faces his own special problems and has his own account to render. At present chemical questions are becoming more and more numerous; when it becomes possible to include a biochemist in the work of this cooperative group, the rate of advancing knowledge should distinctly rise. For it must be clear that the processes involved in leukemia lead us to the basic processes of living matter, and if significant advance in the understanding of these processes is to be made, it will require the concentrated and concerted efforts of many approaches and many forms of technique.

IN QUEST OF GORILLAS

IV. JOYOUS DAYS IN THE KIVU COUNTRY

By Dr. WILLIAM KING GREGORY

CURATOR OF COMPARATIVE ANATOMY AND ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY; PROFESSOR OF PALEONTOLOGY, COLUMBIA UNIVERSITY

THE six weeks that we passed at Tschibinda were so crammed with interest that it is difficult to be brief without losing the freshness of the reality. The place that Raven chose for our camp was in a spot that was ideally beautiful and highly convenient. Immediately behind us was a broad zone of thick jungle of second growth, dotted with many kinds of flowers and covering many acres; behind that was the "gorilla forest," stretching up to the serrate skyline of the mountain. In front of us was an open field of dark brown earth sprinkled with green herbs of various kinds. This field led away from us downward toward the lake, into a fertile little valley which increased in width and depth as it receded from us and was gay with *Erythrina* trees and with light green plantain plants; many of these had erect leaves, some twelve or fourteen feet long. At the right above this valley was a low mountain, dotted here and there with trees. At the left of the valley was another convex elevation with a flaming *Erythrina* tree standing on the top. At the left of this elevation in turn were the sloping, undulating fields of the farm, rising into a good-sized hill at the extreme left.

In the distance in front of us and beyond the brown field was a panorama of lake and mountains, the colors of which changed daily as the hours passed. In the early morning silvery mists would often veil but not obliterate the mountains, which were arranged in purple grays of progressively fainter and more hazy tones, so that one could see eight or more planes, one behind the other. In the midst of the morning sunlight the

—*Photograph by H. C. Raven*

ERYTHRINA TREES IN FRONT OF CAMP.

—*Photograph by H. C. Raven*

NATIVES BUILDING HUT.

mist was thinner and more diffused and there were soft tapestry effects; first the near-by mountains, then the dark lake, then the cut-out-looking, pale greenish-brown mountains on the other side of the lake, then the paler ones in the distance. Our beautiful *Erythrina* tree at the left of the center at such times would glow with color against the tapestry of the background. Above all this, in the entire upper half of the picture, were piled Olympian masses of billowy white clouds, flashing against the cerulean blue.

The whole picture was too immense to show in a photograph. The eye had to wander about over it, while the mind admired the cumulative effects. Late in the afternoon a curtain of mist would often be hung over the distant mountains, and then our *Erythrina* tree would be dark but sharply silhouetted, revealing every cranky angle and twist of its greater and lesser branches and twigs. Nor shall we ever forget a group of three slender trees on top of a rise near the middle of the view from our camp. Bowing demurely toward the mountains, they sent up their light curving stems and from their white upraised arms flung upward a scattering flare of twigs and leaves outlined against the sky.

But there was much to do in camp. While Raven was off hunting gorillas, Engle and I were at work getting Dr. Morton's records, or McGregor and Engle were busy developing the large number of cinema and still negatives already taken. For each of these activities special arrangements and constructions had to be made. In order to have porters ready to cut paths and to bring the two gorillas into camp whenever we should get them, it was necessary to keep with us forty porters, which the district administrator had sent to us from a distant village. They built huts in the little valley immediately in front of our camp. First they cut slender stems and lopped off all side branches. Then they jammed the stems into the ground in a circle, bent the tops of the stems in toward the center and tied them together at the top.

Next they put pliant stems in horizontal zones, weaving them in and out between the verticals. Thus a dome-like basket was formed, with an opening for a door, the joints being tied with twisted plantain leaves. Then they took plantain leaves from eight to fourteen feet long and covered the basket, twining the stems into it, layer after layer, until a fairly rain-proof hut resulted.

Several of the men carried water for the camp, one or two shredded the fiber from banana leaves and twisted it into twine for themselves and us. Two or three were sent at times to Bukavu, twenty-seven miles away, to bring back boxes of groceries and cans of gasolene, etc., on their heads. The forty were in charge of one policeman, representing the government, who tried to prevent them from deserting us by threats of imprisonment. However, we could not fairly expect them to stay more than a couple of weeks, after which we had to get a new lot from somewhere else. They were all most punctual in lining up every few days to receive their pay, which was mostly for the highly congenial work of absorbing an enormous number of sunrays in their black pigment. But when the great day came and Gorilla No. 1 was to be brought into camp, we could muster only nineteen of them, when twice that number were badly needed. At night they would huddle about their fires and then pile in to pack themselves in their little huts.

Meanwhile, however, Dr. Engle and I had literally put them through their paces for Dr. Morton. First we built a level raised path about twenty feet long, upon which we spread out the folding set of boards Dr. Morton had given us. Several men would fill little baskets with earth and throw them on the ground between the parallel strings we had stretched there. Of course there was a crowd of other natives looking on. As there was need of tamping down the earth, I started to stamp on it and clap

—*Photograph by H. C. Raven*

OUR CAMP AT TSCHIBINDA.

THE STRAIGHT TRACKWAY COVERED WITH WHITE PAPER IS SEEN IN THE MIDDLE FOREGROUND.

my hands, seizing a couple of sticks and beating an empty box to imitate a native dance. In a few seconds the mound of earth was covered with a line of grinning savages, stamping and writhing and singing in time with the drumming, which was now being done by one of our own boys, while McGregor was spinning his cinema. When all this was done we spread the row of jointed boards on the mound and were ready to begin operations. Meanwhile we had supervised the erection of a lattice against which was hung a screen marked with squares, from which one could read in the photograph the approximate dimensions of a man standing in front of it.

When all was ready we lined our blacks up and stood them, one by one, in front of the screen, photographing them in front, side and back views. Then we spread a strip of inked cloth over the board walk and over this a strip of white paper held in place by strings and stones. Now our native walks along the paper pathway leaving his footprints, first without a load, then with a load of forty pounds on his head, while McGregor makes a cinema record and Engle makes still photographs. I change the large numbers (which serve to correlate the photographs and footprints), enter the data in a notebook, take the measurements and show the men, women and children where to stand and when to walk along the board walk. Each individual, big or little, receives one franc. Those with missing toes (often due to yaws) or other peculiarities also have their feet photographed. All this takes a lot of time as the wind blows up our paper track, dust falls on the ink strip or rain stops the performance in a hurry. In time, however, we get all our porters and village folks recorded, as the good news of "one franc each" is spread. It was a banner day for this work when the Batwa (pygmies) that had been hunting with Raven came with their dumpy little wives and tiny children to walk over the white track.

—*Photograph by J. H. McGregor*

AT THE END OF THE TRACKWAY.

It is impossible to convey the amusement we derived from seeing each one of these strange beings that lived in a world so extremely different from ours. Let us consider, for example, a great half-circle of our porters and trackers squatting around us on the ground, watching us seated at the breakfast table and waiting for the glad moment when they should stand in line and receive four days' pay (four francs each) from the white man with the shining head (Raven). There is one youth, my special pride and joy, who has one of the most primitive gorilloid noses I have ever gazed at. This proud trait of ancient anthropoid lineage was exceedingly wide at the base, almost as wide as his mouth, with the nostrils facing distinctly forward; the tip of the nose very low (for a human, but well advanced beyond the gorilloid stage), while the wings of the

—*Photograph by H. C. Raven*

MAMBUTI OR BATWA?

THE PYGMIES WEST OF LAKE KIVU ARE NEARLY INTERMEDIATE IN GEOGRAPHIC POSITION BETWEEN THE TRUE BATWA, SOUTHEAST OF THE CONGO ESTUARY, AND THE MAMBUTI OF THE ITURI-UELE DISTRICT. THE PYGMIES ARE WIDELY DISTRIBUTED IN THE FORESTS OVER THE CONGO BASIN.

nose were very wide. Near this youth sits a man with almost the opposite combination of features, namely, a sharp, delicately modelled and (for a Negro) narrow nose set above a fairly creditable mustache and a straggling chin beard. Does this man bear the blood of Hamitic or Semitic invaders from the east and north? Here is another boy with a placid, bovine face, very long and flat, with wide cheek bones; his central upper incisors are very large and his rather small mouth and half-opened thick lips give him an amusing pseudo-mongoloid and semi-idiotic expression. Next him sits one of the elders, reverend and venerable, his face very long and drooped, with exceedingly deep wrinkles across his forehead and around his eyes and mouth. His forehead is bald, nose very wide, recalling that of a five-months' foetus; he has large malformed incisors and projecting ears. He sits crouching with downcast eyes and hands clasped as if in prayer—a poor old Job sitting amid the ruins of his prosperity.

Here sits erect an immense man, Buddha-like in a way, but with an enormous gross face and incorrigible, leering eyes. This black Gargantua thinks perhaps of all the pombé that four francs will buy and inwardly licks his chops. Near him is a Caliban, with broad simian face. This man, by the way, was one of the patients at our involuntary clinic. Yesterday he came again to make the most expressive grimaces and gestures to show where the pain was in his poor old back; and was mightily comforted when we smeared it with iodine and even slipped him an extra franc. Then there is a tall and very skinny ancient who understands a joke. When he had received an aspirin tablet from us for his pains he

grinned knowingly when we gestured to him that our fee for medical treatment was one franc.

Our Batwa (black hunters) are in a little group by themselves, standing with spears erect, watching all that goes on with the keen eyes of hunters. They are supposed to belong to a tribe of forest-living pygmies, but they range from real pygmies to medium-sized people and although they speak a different dialect, they seem to have intermarried with the ordinary blacks. One of their leading men, Nyumba, for example, is by no means a dwarf but a middle-sized man of fine proportions and beautiful muscles. On one wrist is a great brass bracelet. His almost aquiline nose gives him an alert and at times fierce expression. Yesterday he gave us a dramatic and thoroughly convincing representation of himself attacking another man or perhaps a leopard. Snarling and showing his canine teeth, he stamped and raged about the field, zigzagging his flashing knife-point above his head and stabbing with tiger-like ferocity and quickness. But now he sits benignly with the good nature of health and self-approval.

Next to him is Chiliganoa, the Prince Charming of the Batwa, perhaps the most graceful and Adonis-like figure we have seen outside the Luxembourg gallery of statues. Fortunately he is either too poor or too proud to ruin his beauty by wearing white men's clothes; his thin girdle of bright beads well becomes his sable body, while a thick magenta-colored necklace sets off his finely chiseled face. Then comes Nyarikengua, one of the elders of the Batwa, a delicately-formed little old man with narrow, thoughtful-looking face, relatively small thin lips and a projecting chin. Then Karrara, a very friendly little old kobold, with wrinkled face and a slight beard. Then Jukulu, the most comical of all the Batwa, a little middle-aged dwarf with thin chin whiskers and baby-like hands, quite a beau in a small way, with a voluminous dark-blue toga. What a treat it was to see him imitate a gorilla, slapping his chest, making a clucking noise with his lips and running forward in a half-stooping posture. Here would be a cartoonist's idea of the "missing link."

Finally, in front of all these and with a couple of his quaint little boys behind him, sat Cassoura, the little old chief of the Batwa, with the most pithecoid face of them all; enormous wide mouth and broad nose, deep wrinkles on the forehead, on the cheeks and around the mouth, projecting ears and a crown of black wool on top of his closely shaven head.

The people that worked on the agricultural farm also furnished their quota of amusement. Our tents were set on the edge of a field which had been cleared of trees and was finally prepared for agriculture during our stay there. After the stumps had been dug out and stones had been removed, a double row of perhaps twenty-five men armed with hoes began work at one end of the field near our tents. The babel and uproar which arose and continued in undiminishing volume were astounding. The noise of a lot of schoolboys suddenly let into a narrow schoolyard for recess would have seemed dim and far away compared to this. One wondered whether some one would get murdered, but experience showed that each man in each squad merely wanted at all times to be heard and realized that he would have to compete with all the rest. Finally the man in charge would get the line fairly quiet for a brief moment and give the word to go. Up and down flashed the hoes at irregular intervals (the more irregular the better, so far as Private Broadnose cared), but the tongue work was never done. Forward moved the line as slowly as was humanly possible. But at the end of a few hours of this exercise with voice and hoe, the field was well hoed

—*Photograph by J. H. McGregor*

OUR BLACK HUNTERS.

and the shouters were moved away to a less dangerous proximity to our eardrums.

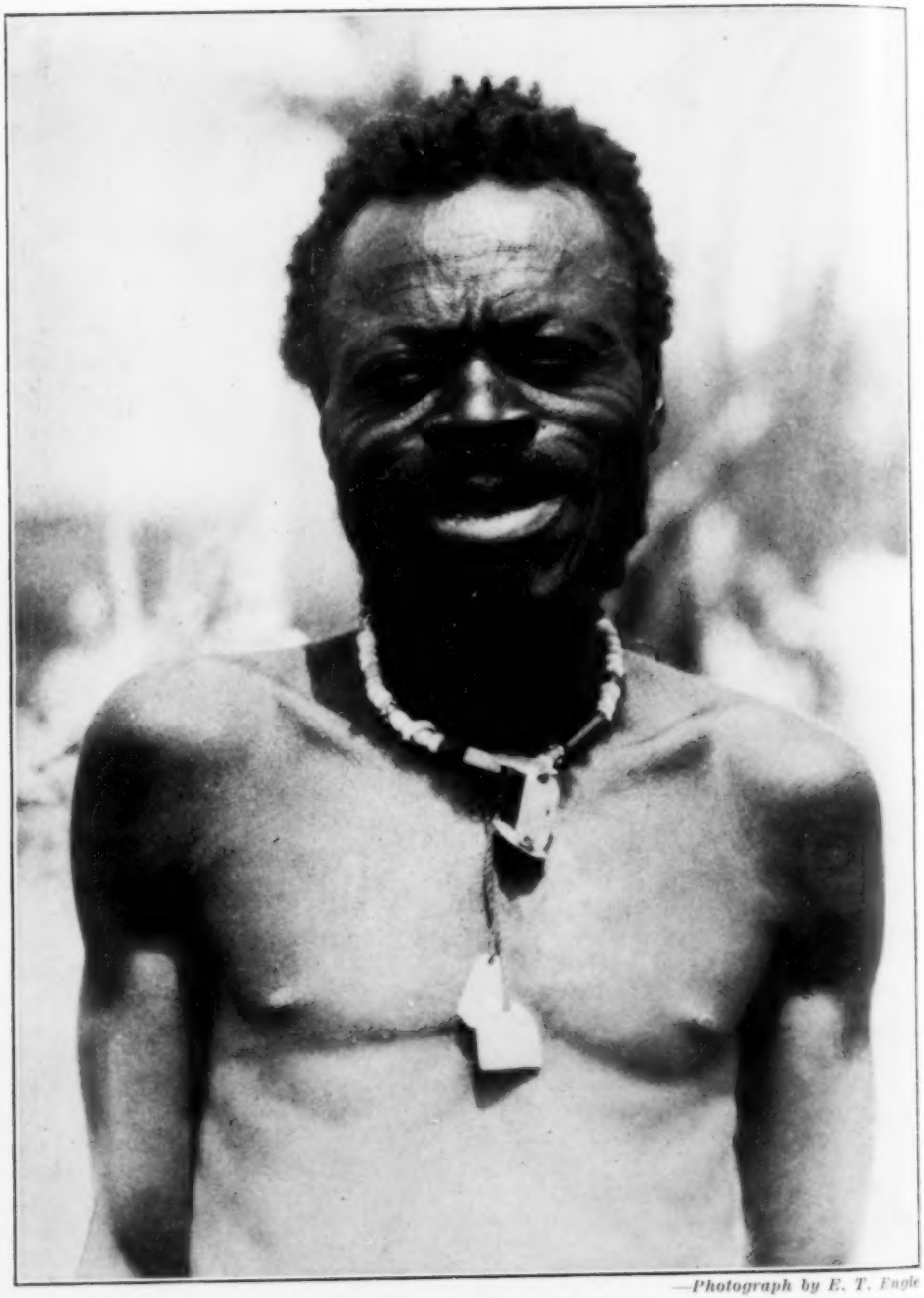
This same field furnished another little scene of human interest. It was traversed by a narrow, very deep, irrigating trench, easy enough for an adult to step over but a formidable obstacle to little folk. Over this trench at its deepest part straggled a woman and three children, each with a water pot on his head, adjusted to size. Baby wobbled along, bringing up the rear with a carefully poised tomato can. Mother and the older children got across the ditch; but Baby found himself cut off by the awesome abyss. Dear me, what a howl he put up. "Help! Help!" One of the older children turned back and lifted him over. In a little while we saw them all coming back from the spring by another route, each with all the dignity of one who walks down a steep hill with a jug of water on his head.

Nor were our excursions to the native villages in the vicinity of Tschibinda less interesting. In many places several families would live within a stockade of light sticks enclosing their houses; these were circular in form, with straw-thatched roofs. Sometimes there would also be miniature houses, occasionally containing fruits and other offerings to the spirits. The houses had neat little doors which could be set in place at night. A fire could be lighted in the middle of the house by the skilful natives without setting fire to the straw roof. Sometimes one would see very old people leaning feebly against the huts. Many babies have dreadful sores, running eyes, etc., and some of them lose a toe or two from yaws. But all bear suffering stoically and snatch what comforts life may bring.

At night fires gleam, the box-pianos drone and the people gather in a circle, while the drums keep up an incessant theme:

Tump-a-tump, tum, tum, tum!
Tump-a-tump, tum, tum, tum!

with droning and clapping chorus.



—*Photograph by E. T. Engle*

A TYPICAL BATWA HUNTER

In general their household effects seemed to be far simpler than those of the people along the Congo River. They use large hollowed gourds to hold water, instead of pottery, and the decorations on these consisted chiefly of obliquely incised lines, said to represent a garden. They make neat matting with little, if any, decoration. They have elongate leaf-shaped knives in wooden scabbards, decorated with incised lines and projecting points. They sold us some neatly woven rattan boxes with hinged lids and clever devices for fastening. Some of the tobacco pipes which we bought had a reed stem and a blackened, well-turned clay bowl, ornamented with a finely woven band of iron wire. At Nakalongi, not far from Tschibinda, Raven and Engle found the native ironsmiths shaping their knives. The most ingenious native iron implement was the "mgoosu" described below.

A walk to a native market, which was about nine miles northeast of Tschibinda, also yielded some interesting glimpses of the natives. As we were in need of meat and wanted to see the country, Engle, McGregor and I took several of our porters and one of our boys to carry our cameras and whatever we might purchase in the market. We had to descend from our camp in the mountains to near the level of the lake, then walk north over a hilly country, then ascend a very steep hill where the market was held; on the way back we had to climb about 1,500 feet at the very end of the trip.

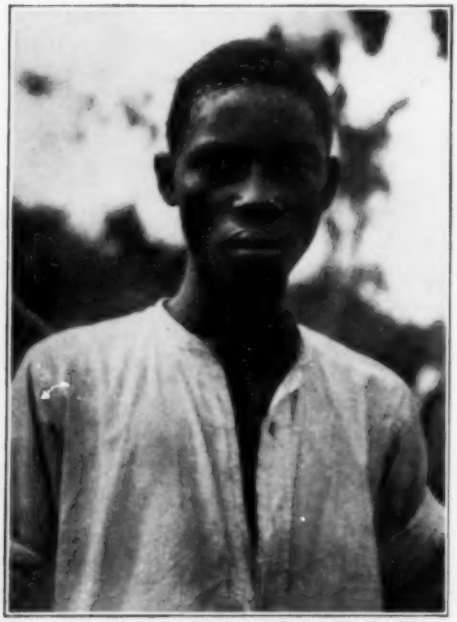
Although we did not arrive at the market until long after the peak of its activity, we could hear the buzz of the all-talking public as we toiled up the steep slopes of the young mountain on which it is held. We did not wonder that some of the women who had carried huge loads up this steep ascent had left their babies in care of several other women whom we had seen minding several babies in a sort of impromptu day-nursery under a shady tree near the foot of the hill.

When we arrived at the top we found a milling crowd of black humanity, which on the whole was not very different from that which we had seen on the market hill in Bukavu. But unlike Bukavu there were no shops here, so that many black merchants had spread out their little stocks of dress-goods, small mirrors, beans, cotton thread, salt cakes, etc., on the ground. There was little if any sale of articles of native manufacture, for which the demand seemed far less than that for foreign merchandise. Our own purchases were limited to a goat, a couple of kids, some beans, etc. McGregor did a lively business in purchasing cinema views of the folks that shuffled about, especially comical old men and assorted women with babies.

Soon after midday we started on the long trek back home; but now we were traveling like pilgrims in a stream of humanity. The women carried their loads of purchases, leaning far forward when going up hill, often with a big baby perched contentedly on top. Among our own followers was little Jukulu, the stout pygmy with short chin whiskers and chubby hands. He had purchased some brilliantly blue cloth, which was now wrapped in graceful folds around his plump black body. He strode along with great satisfaction to himself and to us, skilfully guiding one of the goats with his long wand. We passed a bush fire, which was crackling merrily, but nobody seemed to mind. Then we passed a company of agricultural workers, who were emitting the usual babel. But by the time I had reached the middle levels of our mountain I was interested chiefly in the struggle of forcing myself up the remaining steep slopes leading to camp.

By no means the least entertaining feature of our life at Tschibinda was

—*Photograph by H. C. Raven*
JUKULU.



—*Photograph by H. C. Raven*
POUSSINI.

the opportunity to observe and study our four boys. Poussini the cook, the oldest of the four, who came from near Usumbura, was a slender young man with a long face and a chronically dejected mien, who simply could not be hurried. In a quiet way he was very fond of pombé and of female society. Although always complaining of feeling ill, he never failed to have his fires going and hot meals ready within a reasonable margin of delay, considering how often he was hampered by rains, etc. He took his profession seriously and had a considerable flair for making bean soup. His oatmeal at breakfast was really a triumph. He could not fairly be blamed if the meat of goats and even of kids was unbelievably tough. His greatest ingenuity was displayed, not in making a fire out of wet wood in a pouring rain, but in making some assistant that he usually managed to annex carry water, chop wood and do all the menial work.

Musafiri, Mr. Raven's boy, came from near Baraca on Lake Tanganyika. He was very short, with a great round face and large black eyes. He was easily teachable and did almost everything well that he was taught to do; although fairly slow, he was on the whole rather intelligent and honest.

It was amusing to see the tolerance for fire that Poussini and Musafiri demonstrated by passing their bare hands and feet nonchalantly through the blaze of the campfire, around which we sometimes gathered in the cold mountain evenings, to the amusement and satisfaction of both parties. On one occasion I ostentatiously pretended to imitate them, making very deliberate passes at a safe distance from the flame but exceedingly swift movements when passing through it. This gesture brought out a salvo of laughter and a heartening display of ivory teeth and glinting eyes.

Like other travelers in Africa we soon came to feel an affection for these faithful and amusing creatures, who had elected to follow us wherever we should lead them in the great world. Eventually Raven asked them what were their names for each of us. They told him that his own name was Bwana Para (the bald one), McGregor was Bwana Kitoko (dandy), Engle was Bwana Kapatura (short pants), while I was Bwana Tupi (short).

Behongo, the third of our four boys, would have won the approval of Julius Caesar, who is reported to have said, "Let me have men about me that are fat—sleek-headed men and such as sleep o'nights." Behongo had beautiful dental arches and a comforting smile. In fact I felt that he was almost worth his salary on this account alone. His forte was the laundry work, which he did to our complete satisfaction. At the Catholic mission he had learned to read and write well and could make out a neat bill itemizing the cook's expenditures for food, etc. He went with Mr. Raven on the excursion to Mt. Nakalongi and did excellent work in impressing the people of the neighborhood into helping to carry the gorilla. We all felt sorry when Behongo decided that he had better not go with us on the long journey across Africa, as he had a wife waiting for him in Uvira and a pair of fond parents who, so we were told, were serving a term in prison for eating somebody. Poussini, on the other hand, was free to go with us, as his wife had gone off with somebody else while he was away and he didn't have to bother about alimony.

By far the funniest of our boys was Dr. Engle's boy Matambele. He was very slender and immature, with a swelling abdomen, always gesturing with his long angular arms and slender hands and pouring out a flood of comical language in a high-pitched voice. What a hit he would make on the vaudeville stage! He was the politician and financier of the group and far excelled the others in the art of making the Wapakazi (common "work people") draw water and hew wood for him. He delighted in having hot coffee at our bedsides before breakfast, when we first awoke in the chilly mountain air, and was quick to serve us and even to anticipate our wants. His appearance on one of the nights when

Photograph by H. C. Raven

MUSAFIRI AND BEHONGO.

he went to a dance at Tschibinda was inimitable. His protuberant abdomen was gracefully covered with a white evening shirt and a black vest with sharp points, which he combined with very short khaki breeches. Dr. McGregor and I gave him a white collar and a bow tie and after we had trussed him up in these I got out my shaving mirror so that he could gaze at

—*Photograph by E. T. Engle*

REAL COMFORT.

all this dazzling array. His rapture was complete when we gave him some francs to buy pombé with.

As to the matter of honesty, there were numerous small things about camp that our boys could have stolen if they had wanted to, as it was impossible to keep watch all the time. But we never missed anything, not even francs or half-francs, of which we had to keep a large supply to pay the porters with. We did not attribute superhuman virtues to them, however, and took reasonable precautions against thrusting temptations before them.

I am bound to admit that the natives of Tschibinda, so human and yet so unlike anything we had known, derived equal amusement from looking at us, either staring blankly at the meaningless things we were doing (such as washing negatives and hanging them on a line), or inspecting our strange apparatus. But the gleam of real desire only flashed when they saw a fine, newly-emptied tin can or a discarded razor blade.

The natives at Tschibinda constantly made use of a remarkable implement called a "mgoosu," which enabled them to clear a path quickly even through the thickest underbrush. On the end of a long wooden handle was a shaft of native iron, having near the lower end a long, one-sided blade, and beyond this at the tip a small crescent or sickle with sharply concave edge. A quick swish of this implement while using the sickle part would cut through all thin vines and

branches, while a smart cut with the long blade would eat into a sapling or stout branch. I bought one of these implements from a native and began to cut paths through the jungle immediately back of our camp. The top of this jungle growth in most places was away over one's head, so that going about in it was like navigating on a black night; it had to be done by a sense of direction, which I mostly didn't have.

One day I came to a place very near our camp, which with a moderate amount of work gave me a beautiful "jungle studio." There was a "rotunda" with a natural opening in the center, draped with vines and flowers; through this the sun filtered down to a circular space which I cleared below. A curving path through the jungle and an archway of vines and branches led to the rotunda and a long curving tunnel made an exit behind it, while several bays and exits led off to paths on either side. In fact, many paths, that I cut as time went on, led from this center to various parts of the forest near by. Here I could sit and write, away from the clamor of camp, while many birds flitted in and out and large-eyed wood-mice crept about.

No dangerous animals ever presented themselves to view. Perhaps it was the

—*Photograph by H. C. Raven*

A JUNGLE PATH.

THE TRAIL IS MADE BY ELEPHANTS AND FOLLOWED BY GORILLAS. THE MAN IN THE CENTER CARRIES A *mgoosu*.

—*Photograph by E. T. Engle*

FERNS NEAR MY JUNGLE STUDIO.

wrong season for snakes; at any rate, I never saw one in all the many days that I was rambling about in the jungle and forest. Leopards there might be, perhaps, down in the open fields far below us. We could sometimes hear them yowling at night. Gorillas, unfortunately for me, didn't care for that kind of place, which was too near to human dwellings, but preferred to roam in the forest behind it. The buffalo, a really dangerous animal, was excessively rare in this locality. In all his wanderings in the neighborhood, Raven saw buffalo tracks only once. Elephants appeared once or twice in the vicinity but all too briefly.

In fact, the conventional idea of Africa as a place swarming with dangerous animals, big game, venomous snakes and cannibals, was contradicted by experience on every day of our travels on that continent. These things still exist but in a rapidly diminishing number of localities, while by far the most dangerous creatures are, as always, the amoeba of dysentery, the tsetse fly and the invisible hosts of pathogenic bacteria.

The small mammals, birds and reptiles of Tschibinda were also of considerable zoological interest. We had been there only a short time when some one spoke of a "mole" (taupe) that dug tunnels in the fields. As true moles are not found anywhere in Africa, we suspected that some other kind of animal—presumably a rodent—was passing itself off as a mole. Soon the natives brought in a succession of these "moles," which were mole-like in a general way, having the body stout and short, head blunt, eyes very small, fur very fine. But they

differed completely from moles in having a rat-like head with greatly enlarged chisel-like incisors, by means of which the animal easily cut the stout roots that permeated the soil. The front paws were stout, with well-developed claws but not shovel-like, as in the true moles. McGregor got some excellent cinemas of this rodent (*Georhychus*) as it rapidly scratched and gnawed its way, first making a ditch and then quickly sinking out of sight.

Another and much rarer "mole" in this district was a northern relative of the golden mole of South and East Africa. One living specimen of this curious little animal (*Chrysochloris*) was brought in by the natives and we studied its movements with keen interest. It has a short round tailless body with a conical head and beautiful soft fur, which gives rise to diffraction colors. In contrast with *Georhychus*, its front teeth are minute and delicate and instead of using them to dig with, it depends upon the greatly enlarged claws of its forefeet, with which it can dig trenches and tunnels with amazing celerity.

The occurrence of this animal in the region of Lake Kivu, so far away from the headquarters of its family, brought to the foreground the much discussed question of the origin and history of this family. Undoubtedly the golden moles belong to some group or stock of mammals that has no special relationship to the true moles of the northern hemisphere. Moreover, they resemble the true moles only in such features as are obviously related to the habit of digging in the ground, and we know that in many well-established cases such resemblances have been brought about by convergent evolution between animals of widely diverse origin in adaptation to similar habits. On the other hand, the golden moles also possess a long series of peculiar characters in the skeleton which are collectively found elsewhere only in the families of the tenrecs and their allies of Madagascar, as well as in the so-called otter-shrews of the Belgian Congo. It has therefore been inferred by many authors that the golden moles are the digging, or mole-like representatives of the tenrec family, just as the otter shrews are undoubtedly its semi-aquatic offshoot. But Dr. Robert Broom, the well-known anatomist and paleontologist of South Africa, has discovered that the anatomy of Jacobson's organ in the nasal cavity of the golden moles is very peculiar and

—Photograph by H. C. Raven

A MOLE-LIKE RODENT (*Georhychus*).

—*Photograph by J. H. McGregor*

YOUNG GENETS.

widely different from that of the tenrecs, and he therefore concludes that the golden moles are not, after all, related to the tenrecs. Most students of the problem will, however, be inclined to conclude that this one conspicuous difference, to whatever it may be due, is far outweighed by the many deep-seated and peculiar resemblances that seem to tie the golden moles in with the tenrec family.

Another species of animal that was brought into camp at Tschibinda by the natives was a genet, a small carnivore, a member of the civet family (Viverridae). At the present day this family includes such interesting animals as the suricate of South Africa, a friendly little beast immortalized in Olive Schreiner's "Story of an African Farm," the mungoos of India and Africa, famous for its attacks on poisonous serpents, the genet of Europe and Africa, and the civet of Africa, whose glands yield the base of many perfumes. In Madagascar the family has many representatives, varying from small genet-like forms to the cat-like foussa. Long ago in the days of the four-toed horse (the Eocene epoch of the Age of Mammals) there was a family of carnivores in Europe and North America, in some of which, named *Viverravus* by the late Professor Marsh, the jaws and teeth approached those of the existing civets and genets. The two beautiful little genet kittens which were brought to us alive in our camp at Tschibinda were thus the heirs and living representatives of this extraordinarily ancient family, so it is no wonder that we studied them with keen interest. Their gray fur bore dark, somewhat irregular spots which tended to be arranged in incomplete longitudinal streaks. This is the pattern which is generally believed to have given rise to the more specialized fur patterns among the cat-like carnivores, such as the sharp transverse stripes of the tiger, the circular broken spots of the leopard, the uniform colors of lions and pumas. Our little genets were also interesting in having their claws semi-retractile, that is, intermediate between the non-retractile claws of the ancient fossil carnivores and the fully retractile claws of the cat. Unfortunately, in spite of Dr. McGregor's kind, if forcible, ministrations of milk, they did not live long, but we carefully injected their bodies with preservative fluids so that

they will be valuable documents for future anatomical study.

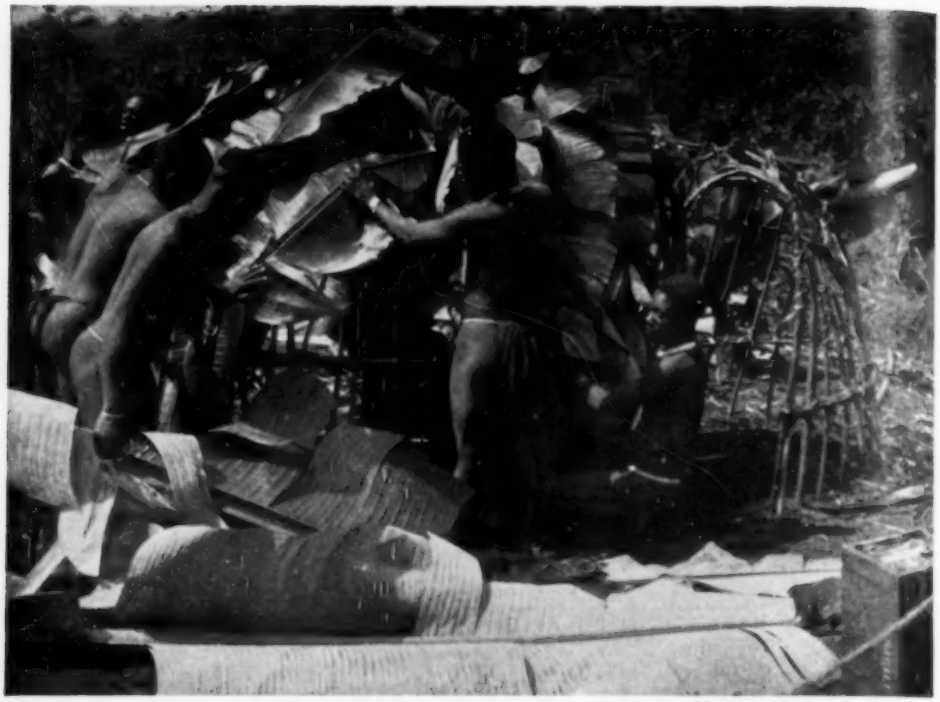
Another curious carnivorous mammal at Tschibinda was a polecat (*Ictonyx zorilla*) belonging to the great family of the martins, weasels, ferrets, badgers and skunks. The body was remarkably elongated and cylindrical between the shoulders and the hips. The head was also bluntly cylindrical, provided with short jaws and excessively strong shearing teeth. The limbs were short, stout and well-clawed, so that the animal seemed well able to pursue the digging rodents into their holes and kill and eat them. This mammal also belongs to a very ancient family which had many representatives in the fossil-bearing formations of Europe and North America. It affords another example of the faunal kinship of modern Africa to that of ancient Europe and Asia.

Aside from a few small lizards the reptiles of Tschibinda were very inconspicuous, with the brilliant exception of the chameleon. These highly curious lizards might occasionally be seen clinging to the vines and branches by their clamp-like hands and feet, very slowly pulling themselves along with elbows and knees widely extended. They have the remarkable power of sneaking up on a resting fly, taking careful aim and then shooting out their enormously extensile tongues with inerrant accuracy, the sticky end of which hits the fly before it can spring into the air. The natives were evidently afraid of these perfectly harmless creatures. Chameleons may be regarded as relics of the Age of Dinosaurs because their ancestors were contemporaneous with the dinosaurs, as we know from certain fossil jaws and teeth.

The birds of Tschibinda were extremely numerous, at least in species. As I sat in my jungle studio they twittered and screeched and literally mocked me in my ignorance of this vast subject. My respect for the ornithologists increased daily as I found out how hard it was to identify any one type of screech with a particular bird, who would rarely "stay put" long enough for one to be sure which was which. I heard no bird songs that could compare in beauty with the songs of our thrushes, but many of the Africans wore brilliant plumage and made up in quantity of song what they lacked in quality. Perhaps the most brilliant bird I saw was one that presented a curious suggestion of a humming-bird, with its whirring wings, iri-

—*Photograph by H. C. Raven*

CHAMELEON.



—*Photograph by H. C. Raven*

NATIVES COVERING FRAMEWORK OF HUT WITH A THATCH OF PLANTAIN LEAVES.

descent blue breast and scarlet throat band. Mr. Raven tells me that this was one of the sun-birds.

During much of our six weeks at Tschibinda McGregor and Engle took and developed a great many cinema and still photographs. They also had an accumulation of negatives from the earlier part of our journey and they felt that it was advisable to develop and fix the negatives in the field in order to protect them against the inroads of the damp and hot climate of the countries through which we were still to travel. Accordingly they had the natives build a temporary dark-room, in the manner described above. Many were the unexpected difficulties they encountered and ingenious were their methods of overcoming them, but to tell of all this would require a chapter by itself.

(To be continued)

THREE QUARTERS OF A CENTURY OF MEDICAL PROGRESS

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SEVENTY-FIVE years ago the status of medicine was not brilliant. Medicine had not yet fully emerged from the speculative era and lacked the foundation upon which to build a real science of medicine, namely, a knowledge of causes. Pasteur was at work, but his researches had not yet greatly fructified the medical field. Nevertheless, an industrious, reticent Scotch Quaker was thinking and a young German country doctor was also thinking along new lines. These men, Lister and Koch, with Pasteur, inaugurated the new era in which to this day we have our being. We are not content with a mere study of symptoms; we are not satisfied to classify diseases on superficial landmarks as was done by that medical Linné, Sauvages,[1] and by his followers. We look for causes and are rarely willing to call a disease an entity unless we have fathomed its cause, though not necessarily its specific cause. That rational attitude we owe to Pasteur and to Koch.

In the period with which we are concerned many causes of disease were discovered—anthrax, wound infection, the septicopyemia of older writers, cholera, tuberculosis, tetanus, meningitis, pneumonia, malaria, syphilis, African sleeping sickness and a number of others. In the first flush of enthusiasm created by these epoch-making discoveries the germ was raised to an all-important position as practically the sole factor in disease. But in recent times the older idea of constitution has again come into medical consciousness. The germ is necessary, but it can only grow if it falls on proper soil. While much nonsense is written about the soil—the human constitution—nonsense that is reminiscent of the notions of the phrenologists, Gall and Spurzheim, the subject is one of vital importance deserving careful study if we are to understand and to master infectious and other diseases.

In the time under review medicine more than ever has shown its catholicity. It has borrowed from the exact sciences all the discoveries that could help in the study and treatment of disease. The triumphs of chemistry have changed the practice of medicine in a way that was far beyond the dreams of Mendeléeff and Lothar Meyer, when in 1869 they announced their fertile generalization of the periodicity of the elements.

Chemistry has revealed to us facts of enormous importance about the composition of the blood. Blood chemical studies are now routine procedures. In my early days the blood was practically untouchable. We bled patients occasionally for the relief of shortness of breath, of cyanosis, in apoplexy, in uremia and eclampsia, but not for the purpose of ascertaining how much sugar, urea, calcium, phosphorus, etc., might be present. It was first necessary for the chemist to discover methods of making these tests without the necessity of abstracting too large amounts of blood. And, marvels of marvels, in recent times methods have been devised of making these tests with mere drops of blood. Blood cultures and Wassermann and agglutination tests, though of a different genre, may be mentioned in this place.

While organic chemistry may be said to have had its birth in 1828 when Woehler synthesized urea, its greatest triumphs

[1] Sauvages enumerates 2,400 different diseases arranged botanical-wise into classes, orders, genera and species.

fall largely in a more recent period. At first analytical, chemistry soon became synthetic, its magical activities resulting in the preparation of dyes and drugs and of substances which were supposed to be produced only in the laboratory of nature, like adrenalin and some of the vitamins. Among the triumphs of chemistry is the discovery of hormones, the impetus for which was given by Bayliss and Starling in 1902. Not only are the hormones of great importance in nearly all vital processes, but they also show us with what minute quantities nature can work large results. That amazing little organ, the pituitary body, practically of no known significance in 1860, is capable of secreting at least eight different active substances,[2] among which those concerned in the sexual cycle are the most recently discovered. The discoveries are coming so rapidly that it is difficult to keep them in order in one's mind. How little we dreamt that the pituitary gland played so important a rôle in the sex life. Perhaps investigators are complicating the subject by postulating so many interacting hormones—nature, after all, may work more simply. The small parathyroid glands, which until 1880 were overlooked, are also marvelous; they control to a large extent the calcium metabolism of the body. The use of the hormones as therapeutic agents has been another tribute to the immense power of chemistry. Collip's discovery of antihormones, while at first confusing the picture we had formed, may help us to explain a number of hidden facts.

To the triumphs of chemistry belongs chemotherapy, the synthetic production of powerful therapeutic agents with which the name of Paul Ehrlich is indissolubly connected. That chemistry has also given us poisonous gases and powerful explosives is but another illustration of the Ormudz and Arhiman principle in human affairs.

Some of the great discoveries of chemistry do not seem to have an immediate application to medicine, but that does not prevent their possible usefulness in the future. Heavy water containing hydrogen of atomic weight 2 and 3 may have biologic properties. It has forced us to give up the original idea of the immutability and unitary character of the chemical elements. The 92 are now represented by about 250 isotopes, many of which may play a rôle in life's processes. The last sixty years have also witnessed the discovery of a number of elements previously missing from the periodic table, so that the list of the 92 is almost complete; and if the work of the young Italian physicist Fermi is substantiated, there may be 93 elements, perhaps more, these last comers being, however, artificially produced.

One other chemical triumph should be mentioned, namely, the discovery of vitamins. Their existence was first suggested in 1841 by Dr. G. Budd, an American physician, but his suggestion bore no fruit. Sir Gowland Hopkins, Mendel, Eijkman, Fraser and Stanton, Hess, McCollum, Mellanby, Chick, Windhaus, are some of the men and women to whom we owe knowledge of these subtle substances which in infinitesimal amounts exert their indispensable action on the body. One ten-thousandth of a milligram of calciferol added to an inadequate diet will sustain the life of a rat that would otherwise succumb on such a diet. This is a further illustration of nature's sparing ways. One might almost be inclined to think that these facts justify Samuel Hahnemann.

The beneficial effects of sunlight on the human body, known from time immemorial, find their explanation, in part at least, in the power of the ultra-violet

[2] Dodds and Noble (*Nature*, May 11, 1935) have described a new substance obtained from the posterior lobe which is capable of inducing macrocytic anemia and gastric hemorrhage in rabbits.

rays to activate certain vitamins otherwise inactive.

The isolation and synthesis of various hormones and vitamins by laboratory workers has been a steady aid to therapeutic advance. It was only after the chemistry was known that the close chemical relationship of many of these vital substances was fully realized. They seem to be formed in nature, almost as if on some chemist's plan, out of the same molecular brickwork.

Practically within the last year it has been shown that substances no less important to the body than cholesterol, vitamin D, the female ovarian hormone, the male testicular hormone, the embryonic organizer hormone (on which Needham has done such startling work), the bile acids and the cardiac stimulants, such as digitalis, are compounds built around the phenanthrene nucleus. Phenanthrene and its isomer anthracene consist of three linked benzol rings and are common constituents of coal tar. Their interest for us until recently was chiefly as the chemical keystones of the dyestuff industry.

It was not long before an even more provocative discovery was made. By laborious processes of purification and analysis it was found that the potent cancer-producing substances in tar had the same structural foundation as this group of vitamins, hormones and bile-products. These researches make it both easy and attractive to think of cancer as some profound metabolic disturbance of cholesterol and bile acid chemistry.

Medicine has also made use of the advances of physics, the most important in this field being the X-ray. Perhaps this is the most important of all discoveries applied to medicine in modern times. I need not dwell upon the significance of Roentgen's discovery. In diagnosis it is indispensable; in treatment it is of great service. Since 1913 when its nature as a form of radiation was revealed, it has given us an insight into the atom and enabled Moseley to arrange the elements in regular order and to explain the mystery of the periodic table. The work of Laue, the Braggs and others with the X-ray has shown that nearly everything in nature is in the last analysis crystalline and every substance liquid or solid reveals to the X-ray the characteristic arrangements of its constituent atoms and molecules.

To the great discoveries in physics of which medicine makes use belongs that of radium by the Curies in 1898. In radium and in the X-ray we have two powerful therapeutic agents, the usefulness of which is destined to increase with time. The discovery of radium and of radioactive substances, some of which are now made artificially, has changed completely the course of physics—that science to-day speaks another language. We may confidently expect that some of its progress will redound to the advantage of medicine.

While the other fundamental discoveries of the physicists, the structure of the atom by Bohr, the mysterious constant of Planck—the quantum—the transmutation of the elements by Lord Rutherford, relativity by Einstein, and wave-mechanics are as yet of no immediate benefit to medicine, no one can say that they may not be. Witness the radio. The cosmic rays discovered by Wulf, Gockel, Hess and Kolhörster, and intensively studied in this country by Millikan, Compton, Swann, Johnson and others, seem to pass through us without our being aware of it. While the penetrating power of the cosmic ray is greater than that of any other radiation known, only a very few fall upon each individual day by day. Whether or not they produce any effect is beyond our present knowledge.

I shall now take up matters more strictly medical. When Meyer of Copenhagen made the discovery of the signifi-

cance of adenoids, he thereby laid the foundation not only of children's health but also of many medical fortunes.

I have spoken of the work of Pasteur, Lister and Koch. I need not dilate upon its transcendent importance for medicine and surgery. Although Ephraim McDowell performed the first ovariotomy in 1809, such operations were few and far between until the era of antisepsis. The first appendectomy in this country was done in 1864 by Willard Parker, but not until Reginald Fitz of Boston wrote his classical paper on "Perforation of the Appendix" did the operation of appendectomy, so life-saving and so profitable for the surgeon, come to be an everyday event.

But surgery has other triumphs. The gall bladder is no longer the *noli me tangere* that it was in the days of my youth. The Graham-Cole test of cholecystography has given to the operation a much surer basis than it had before.

Urology, formerly a minor and hardly respectable specialty, has in our time become an important scientific branch of surgery, the devotees of which have cause to be proud of what they have achieved in hardly more than a generation. Here, too, the X-ray has been of signal service as well as several special chemical tests discovered within the twentieth century.

From the end of the eighteenth century onward we find occasional suggestions in the literature that diseases might be conveyed by insects, but it remained for our own time to prove this with results beyond all expectations. Beginning with Manson's discovery in 1879 of the transmission of filariasis by the mosquito, we have that of Theobald Smith of the tick transmission of Texas fever of cattle, in 1892; three years later Ronald Ross discovered the malaria organism in the mosquito; in 1899 Reed, Carroll, Lazear and Agramonte demonstrated the mosquito transmission of yellow fever, the ulterior consequences of which were the Panama Canal and the disappearance of yellow fever from Central America and from the islands to the south.

The part played by the louse in typhus transmission so dramatically portrayed by Zinsser is a fact acquired at a somewhat later time. In a number of other diseases such transmission is suspected but not proved.

Viruses as a cause of disease were not known fifty years ago. They were discovered at the end of the nineteenth century. To the virus diseases belong smallpox, vaccinia, psittacosis, infantile paralysis, lethargic encephalitis, foot and mouth disease, also probably chickenpox, yellow fever and herpes, as well as a number of diseases of animals. There is still a good deal of discussion as to the nature of viruses. They are much smaller than bacteria—the virus of poliomyelitis is estimated at 10 mμ, which approximates the size of a protein molecule.[3]

The viruses are filtrable and with few exceptions are invisible with the microscope. So small are they that the question has arisen whether they are really organisms at all. Some believe that they originate in the host, but the best recent authorities are of the opinion that they are self-propagating microorganisms.

A filtrable agent in many respects resembling viruses of animal diseases is the bacteriophage discovered independently by Twort and by d'Herelle.

Great advances have been made in our knowledge of the physiology of muscle and nerve. Since Du Bois Reymond it had been customary to regard a nerve as a mere wire, passively transmitting electrical impulses to various organs and muscles. Its only intrinsic property was thought to be resistance to this current, as shown by a wire. Since the turn of the century the work of Parker, Hill, Gasser, Gerard and others has changed this notion completely. The nerve is not

[3] One mμ equals one millionth of a millimeter. The smallest bacteria have a diameter of 750 mμ.

passive, but has a very small but essential metabolic activity. It exhibits no resistance to impulses but indeed propagates these electrical waves itself. Dale and Cannon have amassed much evidence to show that these impulses act only indirectly on a muscle or gland, through the liberation of some chemical substances, acetylcholine and sympathin, at the site of the nerve endings. Accordingly, as the nerve fibers produce acetylcholine or adrenalin-like substances, Sir Henry Dale speaks of them as cholinergic and adrenergic.

Not only has the newer nerve physiology revealed electrical activities and chemical changes in nerves carrying impulses that were scarcely suspected a few years ago, but lately by ingenious apparatus electrical forces have been revealed in the living brain. It would appear as if all vital processes were in the last analysis electrical.

Cerebral localization has been greatly advanced since the days of Broca. This has led to earlier diagnosis of brain lesions and the more successful surgical treatment where such treatment is indicated.

A striking reversal in ideas has also occurred in our explanation of muscle contraction. The energy for muscle activity was produced, so our fathers thought, by the burning of sugar to lactic acid and carbon dioxide. Now we know that the energy of these reactions is produced as heat several seconds after the actual contraction is over. Where, then, does the energy come from which we can transform into muscular work? A large number of substances take part in the process. The following polysyllabic compounds have been found: Hexose diphosphoric and monophosphoric acids, glycerophosphoric acid, phosphoglyceric acid, adenylic acid, phosphoric and pyrophosphoric acids, phosphagen or creatine phosphoric acid, pyruvic acid, methyl glyoxal, glyceraldehyde, dihydroxyacetone, and the end is not yet.

Great advances have been made in our knowledge of the ductless glands; I have already mentioned the pituitary and the parathyroid. It is a revelation to read a text-book of to-day and compare its chapter on the ductless glands with one of fifty years ago. In the case of the thyroid, the adrenals, the pancreas and the sex glands, as well as in that of the pituitary and the parathyroid, our knowledge has been revolutionized. We have hypo-, hyper- and dysfunctioning with characteristic clinical pictures and we have methods of treatment that were not dreamt of fifty years ago. I would not deny that some enthusiasts are "a-babbling of green fields," justifying perhaps David Marine's saying that "endocrinology is endocriminology," but on the whole we are on solid ground.

From the point of view of public health several facts are of transcendent importance: Filtration of water, which has reduced and almost eliminated typhoid fever and the intestinal diseases of childhood; control of hookworm disease, of malaria, of pellagra and yellow fever. Nothing is more inspiring than the campaign against tuberculosis. In the case of typhoid fever and diphtheria, vaccination, immunization and the Schick test have added themselves to the general hygienic measures to reduce these diseases almost, if not quite, to the vanishing point.

The health of the school child has become the concern of the community. Prenatal care likewise is an advance that has come within the memory of men now living. It seems that we have advanced immensely in everything that concerns the protection and prolongation of human life, except in our political economy and in the abolition of war. The political doctors in control of our national health up to a recent time have neither correctly diagnosed nor adequately treated the sick body-politic. Nor have these same statesmen used preventive measures they might well borrow from medicine for the prevention of war.

The Spanish-American war brought in

its train a terrible epidemic of typhoid fever but also and as a consequence a totally altered status of the army doctor. Line officers who had looked with contempt upon the "Saw Bones" of the Army realized that the modern doctor knew more of sanitary science than the general, and that by accepting his advice the health of the army would be preserved. This change in attitude was certainly noticeable in the great war.

In treatment the advances have also been breath-taking. I have alluded to antitoxins; many coal-tar products have been discovered that are useful in relieving pain—we can scarcely do without them. We have salvarsan and other chemotherapeutic agents, insulin for diabetes, and liver therapy in pernicious anemia, a disease that until 1926 had proved invariably fatal. It would appear that the active principle or principles upon which the efficacy of liver depends will soon be isolated—another triumph of modern chemistry.

Blood transfusion should be mentioned in this connection. It is an old method, but it fell into disuse because of its dangers. But since Landsteiner's fundamental discovery of blood groups and through a number of technical advances, the dangers have been so minimized that blood transfusions are daily occurrences in large hospitals.

One of the most important contributions to scientific treatment is the concept of focal infection. While there are obscure references to the subject in the writings of the French surgeon Petit and in those of our own Benjamin Rush, it was not until Frank Billings and Edward C. Rosenow developed the idea that it became part of medical consciousness. It must be admitted that millions of sound teeth have been sacrificed on the altar of focal infection and many other unnecessary operations and procedures have been done, but that does not lessen the value of this great American contribution to medical practice.

There is one therapeutic advance which came about so gradually, so undramatically, that it might easily be overlooked. It is the disappearance of the nauseous polypharmacy that had been bequeathed to us by the Middle Ages. To be just I must give credit for this largely to the disciples of Samuel Hahnemann. Homeopathy has had a totally negligible share in the progress of scientific medicine, but the palatability of its drugs, whatever their actual efficacy, has greatly influenced the art of prescribing of the regular profession.

Technical advances are legion and have redounded to the special advantage of medical diagnosis and of surgery. There are, for example, the methods of removing foreign bodies from the air passages, means for the inspection of internal cavities, the blood pressure apparatus, the electro-cardiograph, the basal metabolism apparatus and many others.

The study of reflexes, which is of incalculable value in the diagnosis of nervous diseases, is also something that has come into use in the last half century.

Advances that can scarcely be overestimated have been made in anesthesia. In my early days the anesthesia was nearly as dangerous as the operation itself. Now all that is changed. In addition to ether and chloroform, the latter rarely used in this country, we have new chemical anesthetics as well as gas anesthesia, spinal anesthesia, local anesthesia with cocaine and its derivatives, and infiltration anesthesia, which since it was first proposed by Schleich in 1890 has come into greater and greater use.

Unfortunately there remain a number of diseases that are as recalcitrant to treatment as ever—leukemia, multiple sclerosis, paralysis agitans, cancer of internal organs and Hodgkin's disease.

I am not sure whether the addition of new disease can be considered an advance. Nevertheless, the recognition of such diseases is creditable to medicine.

It is not necessary to mention all the diseases that have been added to our nosology in the last 75 years. I shall name only a few—Vincent's angina, trench fever, infectious jaundice, paratyphoid fever, botulism, undulant and abortus fever, lethargic encephalitis, tularemia, psittacosis, pneumoconiosis, agranulocytosis, infectious mononucleosis, coccidioides granuloma and acromegaly.

Psychiatry or the study of diseases of the mind was one of the last branches of medicine to feel the fructifying effects of modern science. Living in a cloistered atmosphere the psychiatrist was concerned mainly with classifying mental diseases and administering such meager treatment as he knew. On the outside, *fuori le mura,* men were busily studying the mind by new methods, and these methods have done more to clarify the activities both of the normal and of the diseased mind than all the studies since the days of Benjamin Rush, the first American to concern himself with mental aberrations. The work of Freud, Jung, Adler, Alexander, whatever one may think of its therapeutic value, is beyond doubt of enormous significance for the understanding of the normal and the abnormal human psyche. And the terminology created by psychoanalysis —complexes, inhibitions, frustrations, superego, sublimation—has become an integral part of all civilized languages. General literature has absorbed the newer ideas and industry has applied them to its workmen, the army to its soldiers, and colleges to their students.

Perhaps the greatest advances of all have been in the domain of medical education. The extension from a two years' course or the apprentice system to a three years' course and eventually to a four years' course, the disappearance of proprietary schools run for profit, the internship, the laboratory, state boards of examiners—all these advances have been of immeasurable benefit to medicine and to the public weal. Belonging to the same category are the great research institutions of which the Rockefeller Institute for Medical Research is an example. The Mayo Clinic, a typical American product and deserving to rank as the eighth wonder of the world, has also been an important factor in medical education.

In the education of medical men the medical journal occupies a prominent place. There are too many journals, but on the whole that is a lesser fault than too few. The American Medical Association and its *Journal* have been important factors in improving medical schools and in educating students and physicians.

I have one complaint to make with regard to medical education—it takes too long. I do not mean to say that the medical course itself is too long or that the one or two years' internship should be shortened or abandoned; it is the premedical course that takes too long. At the present time a student rarely enters the practice of medicine before he is twenty-eight or twenty-nine years of age and it takes a few years thereafter for him to make a livelihood. This imposes a great burden upon the parents. The principal way of shortening this is to speed up primary and secondary and college education. The study of medicine should be begun at not later than twenty—Laënnec began at fourteen and a half years. There is no reason why the college course could not be shortened to three years, and the high-school course also.

I can not refrain from saying a word about the full-time system of clinical teaching, the introduction of which into medical education we owe to Abraham Flexner and the late William H. Welch. The ideal underlying this plan is certainly correct, namely, that the teachers of medicine should give a large part of their time to the job of teaching. When many of us were in medical schools, the professor of medicine and the professor

of surgery were busy practitioners and had little time for their pedagogical duties. It is a question, however, whether the extreme academic method advocated by some educators is the best. At any rate, there should be on every faculty a group of clinical teachers who are practicing extramurally and can bring to the student a point of view that no intramural teacher can bring. Such clinical teachers should have proper faculty standing and academic honors as well as salaries commensurate with their abilities. Such men whom we might call part-time teachers are necessary if the student is to get a complete picture of medical practice.

Trained nursing belongs to the advances of medicine. Trained nursing had its origin in Germany, was improved in England and perfected in this country, where it began but little over fifty years ago, yet it has achieved triumphs beyond all expectations. No one can dispute the statement that the American trained nurse has no peer anywhere in the world.

Social service is also a medical advance belonging to our time. It is an indispensable adjunct to medical treatment in hospitals and out-patient departments.

Besides the trained nurse and the social worker there is a third female adjunct to medical practice that did not exist in the last century, namely, the technician. If it were not for her the time-consuming laboratory studies that are now so universally made would not be possible, for the doctors never could find time to do them. Furthermore, much of the research work would be hampered if there were not technicians to do the simpler things.

Seventy-five years ago there were two branches of medical practice—medicine and surgery. The surgeon did everything that could be done with the knife and the medical man did everything else. Both did obstetrics and the surgeon usually also practiced medicine. The first specialist probably was the ophthalmologist and he was looked down upon as being unethical. What a change has come over the picture. Medicine is split up into almost countless specialties, each one organized into a closed society, each one with journals and text-books of its own, each one thinking that it is the most important branch of medicine, and each more and more ignoring every other department of the healing art. While in a sense such splitting up is regrettable in that it narrows medical practitioners, nevertheless it has resulted in great advances. The most recent split-ups are cardiology, allergy and angiology or diseases of the blood vessels. None of them is really a specialty; it should be understood by every practicing physician, but because men have devoted themselves exclusively to them, advances have been made that could not well have been made otherwise. The analytical process, I believe, will go on, for synthesis is not possible, the individual fields are too vast.

A subject that is probably as old as the practice of medicine itself is that of medical economics. Yet at no time in history has it occupied so prominent a place either in medical consciousness or in the lay mind as now. Should I include it among the advances of medicine? The answer depends on our point of view, whether we are social-minded or individualistic in our *Weltanschauung*. It would carry me too far afield if I were to discuss this subject, which seems to have divided the medical profession as states rights and slavery divided our nation seventy-five years ago. Perhaps it will require something like a civil war—of words and ideas—to settle the question, and when settled the outcome may perhaps be ranked by future historians among the greatest advances of all in medicine.

AUDITORY PERSPECTIVE

By JOHN MILLS

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PERHAPS you are reading this article by artificial light. Even under the best of conditions light is not uniformly distributed and areas equally distant from the source are not equally illuminated. A quick glance around a room will tell whether or not that is so. In the sweep of the eye a comparison is made of the brightness of similar surfaces. So natural is such a judgment that if one picks up a book in an irregularly lighted room he instinctively turns or moves to a position of more adequate illumination.

An ocular comparison of this character is possible only when the intensity of the radiation from the lamp remains constant during the series of observations. You can not be sure that one corner of a room is darker than another if, while you turn from one to the other, the light source changes in brilliancy. It is also necessary for accurate judgment that the surfaces which are compared shall be similar in texture and color and in the angle at which they reflect to the observer.

Instead of light let there be a source of sound. It is now impossible from a single position to draw any conclusion whatever as to the distribution of the sound. The only way a comparison can be made is by placing one's ear successively at the locations which are to be compared. Since this is awkward and a human ear is not a good measuring instrument for a series of determinations of acoustic power, it is usual to employ an electrical ear. A microphone can be mounted on an arm, or boom, to swing around the source of sound; and the current can be recorded continuously as its position changes. In that way the sound intensity can be obtained for each angular degree around the circle.

Such data are presented most conveniently in what is known as a polar plot. On a sheet of paper place a dot and radially from it draw lines in every direction. Give to each line a length proportional to the intensity of the sound in that direction. Usually the interest is in only half the possible directions, namely, those within 90 degrees on either side of the direction in which the sound source faces. If it radiates uniformly over this 180 degrees the plot will be half of a circle; but generally the graph resembles a leaf of a plant, as does that for the sound from a violin.

If a blindfolded and one-eared listener were swung slowly around a semicircle with a violinist at its center he would probably insist that he was being moved back and forth from the source. Without eyes to aid and without the ability to judge direction which is the important phenomenon of binaural audition, changes in intensity must be associated with changes of distance. When this hypothetical listener is in the position to face directly the violin—not the violinist—the sound he receives may be eight or ten times as intense as that he will receive in most of the other possible positions.

Imagine the violinist to face a battery of microphones, so arranged that their combined output is always the maximum power of his instrument, regardless of his changing position. Now translate the current through a loudspeaker which will distribute the sound with practical uniformity in all directions. No one in the audience of the loudspeaker is then subjected to partiality; and all hear exactly what the violinist plays. A properly designed loudspeaker can distribute music through a hall so that the direct sound is the same for all listeners at the

same distance from the speaker. There would be obvious box-office advantages to a system which could deliver to all seats alike; but there is another aspect to be considered.

What a loudspeaker can deliver so impartially must first be collected by a microphone. This electrical ear picks up the same sound as would a one-eared listener in its place. When the source of sound is a soloist, microphone and monaural listener are at no disadvantage as compared to a binaural observer. This is true also, of course, whenever the music arises from a group of sources, as for example a band, provided it is far enough away. For an orchestra in an ordinary auditorium, where the instruments are distributed throughout a considerable angle, the binaural listener has the advantage. He can detect the direction of the individual sources.

Aural localization of the direction from which a sound comes has its physical basis in the different effects which the wave produces in the two ears. One of the obvious differences, but one usually of least importance, is in the time of arrival of the wave at the opposite ears. When one hears a short sharp sound, like a tick or click, he tends instinctively to turn toward the side on which it was heard first.

Another difference, which is particularly important when the sound is complex, is that of quality. The high-frequency components of a sound are propagated in short waves. For example, at ordinary room temperature the wave-length of a pure tone of 1,134 cycles is one foot; of 2,268 cycles, six inches, which is about the shortest distance between ears, and of 8,000 cycles, a component of some speech sibilants, only one and three quarter inches. Whether or not a wave train casts a sharp shadow depends upon the size of the obstacle as compared to the wave-length. Just as a pin point will form a shadow to a light, so objects as small as the human features will shade from a radiation of high-pitched sound. Listen to speech with one ear and notice how much more pronounced are the consonantal sounds when the speaker faces the ear and the short waves have direct access to the canal. Because of such effects, when one listens binaurally to complex sounds from elsewhere than directly ahead, or behind, the overtone quality is bound to be different at the two ears.

For the middle range of audible frequencies, for which the wave-lengths are larger and the shielding can never be complete, the head itself will shield enough to make appreciable difference in loudness at the two ears. Imagine an observer, with his left ear plugged, while a source of steady sound swings around his right side from directly in front to exactly behind. The loudness increases until the source is almost opposite the right ear; then drops; about three quarters of the way around it falls slightly below the value it had when the source was straight ahead. When the experiment is tried by stopping the right ear instead of the left, but moving the source as before, the loudness decreases more rapidly because the head then acts as a shield. It reaches a minimum when the source is about opposite the right ear and gradually increases, ending at the same value as it did for the right ear.

In binaural hearing each ear functions as just described. The more nearly the sound is directed into one ear, the louder it seems to that ear and more than equally weaker to the other. For speech the difference in intensity may correspond[1] to a power ratio of ten to one.

When the sound is of low frequency, and is not rich in overtones on the basis of which quality differences may be perceived, its wave-length is so large as compared to the human head that there is no shielding and no appreciable difference

[1] For more complete data see the chapter entitled "Plots and Graphs" in "A Fugue in Cycles and Bels."

in loudness. This is particularly true for pure tones below about middle C. In that case the source cannot be located by unaided ears. The sound lacks direction and seems to pervade the surrounding space.

Localization, however, is possible by utilizing a pair of electrical ears with greater separation than is human. Two microphones may be mounted at opposite ends of a long rod, arranged to swing on a pivot at its center. The microphones connect respectively to right and left head-receivers. In the simplest case, the rod with its electrical ears is turned until to the listener the sound seems directly ahead; then the line connecting the microphones will be at right angles to the direction of the sound. This fundamental principle was employed in the world war in the location of airplanes in flight. There is no shielding, however, and the localization is due to the difference in time of arrival of the successive condensations at the two electrical ears. There is, in other words, a difference of phase at the two microphones when the sound arrives obliquely.

Human ears, when sight or the sense of touch also do not supply evidence, can be completely fooled as to direction.[2] Imagine a small stage on which, RU and LU, are two loudspeakers concealed by a front drop. The listener occupies a center seat a few rows back. Current for the speakers comes from a single microphone offstage, but the output of each speaker is separately controlled. A solo artist is before the microphone and the loudspeakers are set for equal volumes. To the listener the soloist is unmistakably just behind the center of the curtain. Next, the output of one speaker is gradually increased, while the other is decreased. The artist apparently is moving behind the curtain toward the more intense speaker. A net difference of about 12 decibels[3] between loudspeakers will walk him to one side of the stage; and then 24 in the opposite direction will move him to the opposite side.

A more flexible arrangement is obtained when the two loudspeakers are supplied by independent microphones. A portion of the offstage room is then laid out as a miniature or studio stage. On a line in front of this stage, and widely separated, are mounted the microphones. The outputs of the loudspeakers correspond respectively to what the microphones pick up. If a performer on the miniature stage is nearer one microphone than the other, to the listener he will have an acoustical image which will occupy a corresponding position on the curtained stage. As he moves, and so changes the relative proportions which the microphones receive of his acoustic output, his image will move correspondingly. All sounds on the studio stage are thus reproduced in their spatial relationships.

Through the application of this principle of binaural audition, and by the utilization of high-quality microphones and loudspeakers, it is possible to reproduce with essential illusion an orchestral performance. Somewhat better illusion, as to location front and back, is obtained when three channels are used instead of the two just described. In that case there is provided for the miniature stage a third and centrally placed microphone which is connected to a loudspeaker midway between the other two. This third channel is also particularly advantageous when vocal soloists are to be accompanied by an orchestra.

It was this three-channel system which was used in the first demonstration of transmission and reproduction in auditory perspective. That took place on

[2] An early illustration was "Oscar" in the Bell System exhibit at the 1933 Exposition in Chicago, which is described in the chapter on "Extensions of the Senses" in "Signals and Speech in Electrical Communication."

[3] That means making the sound from one loudspeaker about 16 times as intense as that from the other.

April 27, 1933, under the auspices of the National Academy of Sciences, before whom at an earlier meeting there had been presented a technical discussion of the method and equipment. The demonstration marked the conclusion of a series of telephonic researches in which Dr. Leopold Stokowski and the Philadelphia Orchestra had generously assisted. In Constitution Hall in Washington a large audience of music lovers and scientists listened to the reproduction of a program rendered by the orchestra in Philadelphia under the leadership of Associate Conductor Alexander Smallens. Transmission between microphone and loudspeaker was over specially arranged telephone lines. The electro-acoustical system was demonstrated later at Philadelphia, with the orchestra playing in an offstage room; and still later in New York City before various engineering societies, with another and smaller orchestra.

The original demonstration was certainly an historic occasion from the view-point either of music or of electrical communication. Although it was a complete presentation of the new instrumentalities which science had made available to musicians, the emphasis was not upon how the electrons went around but upon the heights to which they could carry a listener. Representative selections from Bach, Beethoven, Debussy and Wagner were interpreted by Dr. Stokowski. For that purpose the dial controls of the electrical equipment were located in a first-row box at the rear of Constitution Hall, from which point he conditioned the music of the distant orchestra to bring it into accord with his own ideal. From the scientific standpoint, however, from which the system must be considered if its potentialities are to be appreciated, the demonstration was not single featured; instead it presented a number of aspects.

First of importance was the fact that the equipment and transmission facilities of each channel picked up, transmitted and reproduced all the musical sound presented to its microphone which an ordinary human ear could perceive. All components of the music within the range from 40 to 15,000 cycles were faithfully reproduced. Further, there was no compression of the volume range; there was reproduced the full intensity range of the orchestra, a total of 70 decibels, representing for power of *ff* as compared to that of *pp* a ratio of 10,000,000 to 1.

Of similar importance was the arrangement and utilization of three channels whereby the reproduced music was presented in auditory perspective. Not only did this create an illusion, because the instrumental sounds seemed to arise from their usual orchestral positions on the stage, but more importantly it provided the same spreading of music throughout the hall as would have been produced if the orchestra had been present. In that way the "stereophonic" system recreated an atmosphere of sound not perceptibly different from that of a local orchestra. Without that atmosphere, which previous methods of electrical reproduction were unable to provide, music is one dimensional and lacks its true spatial relationships; it lacks in richness and texture.

Through the multichannel system of microphones, lines, amplifiers and loudspeakers, properly disposed according to the principle of auditory perspective and binaural audition, there may be reproduced in one auditorium all that ear could perceive of the music which occurs in a distant auditorium. In addition, however, the electrical system was developed and arranged to provide three extensions of music, carrying it beyond its inherent limitations and making possible new artistic effects. These three aspects of the demonstration were completely under the control of Dr. Stokowski, who was thus able to produce according to his imagination tonal effects and

intensities beyond previous human possibilities, but not necessarily beyond the dreams of composers like Wagner.

The relative importance of these extensions, artistically, may well be a matter of debate. To the present writer, who can justify his choice only on the non-artistic basis "I know what I like," it is enough to have heard the finale of Götterdammerung played at full power under Dr. Stokowski's direction; and rising above its most stupendous crescendos, the liquid notes of an unstrained solo voice! The soloist can sing to the central microphone while the other two pick up the orchestra for stereophonic reproduction; and the intensity level of the solo channel can be raised to bring the vocal portion into any desired relationship.

It may well be that the increase of intensity range will ultimately prove to be the extension of greatest importance. Not only can the equipment handle the full 70 decibels range of a large orchestra, but it can transmit and reproduce without overloading, and its consequent distortion, a range of 100 decibels. Allowing 10 decibels for the masking of sound by audience noise, this means practically full use of the hearing range of the human ear. Because the equipment can provide and tolerate about 20 decibels more amplification than is needed to reproduce the loudest orchestral music at its original intensity, it becomes possible for a director who controls its dials to increase his orchestra a hundred times. By the turn of a handle he can make its output that of a hundred times as many instruments, but all in the relatively small space required for a normal orchestra. He can also produce musical sounds very close indeed to the threshold of pain!

The last of the three extensions is accomplished by the introduction into the transmission system, between microphone and loudspeaker, of networks designed to discriminate against certain pitches. Dials then provide the director with a tapering control for the relative intensities of the components in the music. When he so desires he can enhance all the lower harmonics, emphasizing them the more the lower their frequencies. Or he may minimize their sounds to an equal degree. For the high-frequency components several steps of control were provided, permitting them to be discriminated against with greater severity. In that way thin tones may be eliminated and an unnatural color given to the music. If the high frequencies are reduced while the low are increased a maximum effect is produced.

What the final judgments on these effects will be, no one knows. Music and art must move slowly, for they are deeply rooted in the emotions and traditions.

These controls can, of course, be applied equally well to music other than orchestral, for example, to choir or chorus. Antiphonal effects can be enhanced or imitated by variations of the relative intensities of the right and left channels. Groups of instruments can be emphasized through the central microphone and loudspeaker. And all these, and other effects as yet untried, can be superimposed upon music completely reproduced in all its spatial relationships. The moment—and that moment occurred in the spring of 1933—when it became possible electrically to reproduce all the sounds of orchestral music, there was passed the boundary between natural and electrical music. For better or for worse, we are entering an important new period in the development of music.

THE LOST ART OF HARDENING COPPER

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DOWN the centuries from dim and distant days come strange, enchanting legends. Many of them are indeed well worth repeating, some of them continue to exert a rather surprising influence, all of them should be favored with a kindly skepticism. *Cum grano salis* is still an excellent prescription.

It is a human characteristic to treasure the traditions of a Golden Age of the long ago. There are tales which tell of happy lands now lost beneath the sea. There were men who lived long and robust lives. There were crafts and skills that can no more be attained. There were methods of working with materials and feats of engineering which still defy complete explanation. There were giants in those days.

If we could but find the keys to those precious secrets of the past—if we could but regain a knowledge of those long lost arts—what fame and fortune might not be ours?

It was in the year 1838 that an American orator of some note, Wendell Phillips, first delivered his now famous lecture on the "Lost Arts." This colorful discourse was accorded such a hearty reception that it came to be repeated over two thousand times during the succeeding forty-five years. It made a profound impression upon audiences of the Victorian Era. Many of the amazing modern applications of new ideas developing in the fundamental sciences were just around the corner, yet unsuspected by a world they were so soon to transform. It was still possible to thrill lyceum gatherings with tales of ancient miracles, many of which, even if true, would seem rather tame to twentieth century schoolboys.

There were, of course, some real wonders in that ancient world. Certain very remarkable skills were developed in more than one field of human endeavor. The evidence may be found not only in historical documents, but also in actual material objects which have survived the centuries. The great Pyramids of Egypt are obvious and trite examples. Even in times now considered ancient, they served as specimens of past glories. Travelers in the days of Alexander and tourists in a world ruled by the Caesars had a thoroughly modern attitude towards the old Pyramids. In the manner peculiar to sightseers, they came, they saw and left their marks on the already aged stones.

There are fragmentary records which contain allusions to many another great wonder of olden times. It is possible, however, by a careless or inaccurate translation of certain vague passages, to arrive at some quite absurd conclusions. Wendell Phillips applied his own unique interpretations, with most interesting results.

The popular lecturer apparently expected to be taken seriously when he spoke of the steam engines and railroads of ancient Egypt, when he declared that it was the custom of Nero to view the arena through an opera-glass, when he inferred that the Temple of Solomon was equipped with lightning-rods.

According to Mr. Phillips, it was not only in the scientific fields that everything had been worked out by men of bygone ages. Centuries ago every possible social problem had been talked into

rags by the parlor pinks of old Alexandria. And no doubt the lecturer was uncomfortably near the truth when he asserted that all jokes could be traced back to the wits of Athens.

Regarding one of the revered sciences, Mr. Phillips is quoted as remarking that "The Chemistry of the most ancient period had reached a point which we have never even approached, and which we are in a vain attempt to reach today." One is told that modern dyes can not begin to compare with those of olden times either in quality or variety. Steel swords were tempered to sever the finest threads and to fit into their scabbards like corkscrews. It is reported that the first travelers in Africa found a tribe in the interior with whom they traded razors, receiving in exchange metal blades the like of which had not been seen in so-called civilized countries. The tale is told of the Hindoo maiden who wore seven suits of muslin which were of so thin a texture that her father was moved to remonstrate with her for going about unclothed. Strange stories from many lands!

Glass that was discovered by accident while sailors sat around their fire on the seashore. Glass that was so flexible that if supported by one end, it would by its own weight dwindle down to a fine thread, so that it could be curved around the wrist. Glass that was really transparent and hard, but not brittle. Glass that when dashed upon a marble floor was bruised, but not broken. Glass that was pliable and could be re-shaped with a hammer.

As with the stories about the "universal solvent," certain very obvious and awkward questions must have occurred to discriminating auditors of the unbreakable glass fables. It was customary, however, to anticipate some of the objections and to squelch them with an explanation that was deemed quite unassailable. It appears that a crafty Caesar had the inventor put to death and threw all the malleable glass articles into the Tiber—thus the wonderful secret was lost.

Some curious references to very minute carvings and writings offered starting points for still other remarkable deductions. A complete copy of the Iliad was said to have been written on a skin so small that it could be contained in a nutshell (the variety of nut was not specified). From this and stories of like nature, Mr. Phillips concluded that the ancients possessed magnifying instruments and even had some knowledge of photography. In somewhat the same manner, it was argued that the old pirate, Mauritius, had a marine telescope, because of the reports that he was able to see ships far out at sea.

A frequently quoted tribute to the craftsmen of olden times is that their mortar outlasted the stones it cemented. However that may be, they did indeed build better than they knew. Long after the mortar and the stones alike have crumbled into dust, the traditions of ancient glories will be the living residues.

Among the legends which continue to exert their peculiar fascination are those which tell of the lost art of hardening and tempering copper. From a verse in the fourth chapter of Genesis to page one of this morning's newspaper, there have been rumors of priceless secrets about the red metal. Tucked away among the "begats" one may find the phrase that relates how Tubal Cain was "an instructor of every artificier in brass," which has suggested that he had some knowledge of the magic method. Newspaper columns of recent years prove that carefully prepared explanations, no matter how authoritative, can not dampen the enthusiasm of latter-day seekers.

The search goes on—a quest for the long lost art that made the metal of Venus supreme in the ancient world.

Old mythologies relate that when the goddess of love and beauty rose from the sea on the shore of the Isle of Cyprus, a looking-glass made of burnished copper served as her mirror. Whatever the explanation, certain ideas regarding Venus and mirrors, Cyprus and copper, came to be associated in the mystic sign of a circle and a cross. The name given to the red metal by the Romans derives from the beautiful island on which it was mined and the old Latin word passed, with slight modifications, into modern languages. For the Egyptians the ancient Ankh symbol had yet another significance which was most appropriate in relation to copper. It was the token of an enduring life.

The museums of the world house a vast collection of ancient articles made of copper and its alloys. Time has been kinder to this metal than to the less durable one which eventually supplanted it.

Thus it is that copper relics of every sort have survived—daggers and dishes, needles and necklets, rivets and rings, scissors and swords, tweezers and toys—almost everything imaginable, and some things of which the precise meaning is in doubt. There is, for example, the celebrated set of four sharp-bladed implements, held together by a ring and incased in a funnel-like protector of metallic copper. This Babylonian curiosity has been described variously as a group of surgical instruments, as an assortment of engraver's tools and as a manicure set.

In the Mediterranean countries the Ages of Copper and of Bronze were passing in the early days of Rome, but in some parts of the world they have persisted until recent times. Various factors relative to the natural occurrences of metals have always had the greatest influence upon their exploitation. It seems reasonable to assume, therefore, that most primitive peoples became acquainted first with the so-called noble metals—copper, silver and gold.

Occurrences of these elements in the simple metallic form are not as rare as might be supposed and they are, in small amounts at least, rather widely distributed over the surface of the earth. It becomes increasingly difficult to find them and one is inclined to underestimate the sources available to ancient peoples. Long ago most of the easily discovered grains, the more accessible ores, the readily mined deposits, were all cashed in.

In the older civilizations there came a time when bits of metallic copper began to be hard to find. Fortunately, it was not necessary to devise elaborate furnaces in order to reduce the ores of this metal. Many complicated theories have been advanced to explain the origin of smelting processes. The chances are that the methods resulted from observations of accidental preparations. Moreover, it should be recognized that the accident must have been an event which had a high degree of probability. It must have been an accident which many individuals had an opportunity to observe before its immense importance was fully realized. These considerations count against, for example, the theory that the process had its origin in the dropping of a piece of malachite paste, used by Egyptian ladies as a cosmetic, in the charcoal fire of a brazier.

The suggestions of the late William Gowland, of the Royal School of Mines, have been most generally accepted. There seem to be good reasons for believing that the camp-fire was the first primitive smelter. Whenever the ring of stones about a fire contained metallic compounds, or the fire was built upon an outcrop of metal-bearing rock, conditions were favorable for a reduction process. Puzzling over bits of metal found in the ashes, some one happened to suspect the connection between them and proceeded to perform a few simple

experiments. The formation of a shallow cavity to receive the molten metal was an obvious improvement and, as it was deepened, the familiar shape of a metallurgical furnace began to emerge.

The use of the copper carbonate, malachite, by the ladies of Egypt probably did have something to do with the operation of the world's oldest copper mines. Apparently they were worked for their malachite and turquoise by the great Pharaohs, possibly as early as 5000 B.C. The mines were located in the wilderness of a little peninsula destined to be made famous by a people who wandered around in it for forty years.

In an age dominated by the red metal, mining activities spread around the Mediterranean, from the mountainous wilderness of Sinai to the Isle of Cyprus and the Rio Tinto of Spain.

With the development of methods for extracting copper from its compounds and with the discovery of large deposits of its ores, the use of this metal expanded rapidly among the artisans of olden times. The properties of copper were, of course, of the greatest importance in determining the significant part it played in the rise of most early civilizations.

The outstanding chemical characteristic of the noble metals, copper, silver and gold, is their resistance to corrosion, which guarantees a long life and enduring beauty to objects into which they are fabricated. In their physical properties these metals exhibit something of a paradox. They are all comparatively soft, but also very tough and tenacious. Thus they excel all other metals in ductility, the property involved in drawing them into fine wires, and in malleability, the property which permits them to be rolled into thin sheets. These qualities are most admirable for many modern purposes, but the ancients were not interested, for instance, in the stringing of telephone wires.

Efficient tools were a vital concern in the lives of early peoples. Instruments were needed which combined toughness with hardness—hardness in cutting or abrasive action on other objects. It was a combination that was not easy to find. In ordinary cutting operations hardness was the prime requirement and many natural abrasives came to be used. Flints and quartzites were hard, but also were brittle and easily broken. The diamond is a familiar example of extreme hardness accompanied by a distressing brittleness, and rubber exemplifies how softness may be allied with unusual toughness. It was to metals that men turned in an effort to secure the best combination of those highly desirable attributes—toughness and hardness.

Copper could not assume its important place in the arts and crafts of ancient peoples until methods of hardening it were discovered. In the smelting of copper ores and in the fashioning of copper objects, it was inevitable that certain favorable conditions were noted and remembered. During some prehistoric period the problem was solved to a degree that was more or less satisfactory. There were and are two general methods by which copper was long ago and still may be hardened.

Mechanical working of copper notably increases its hardness. In shaping bits of metal into a desired form, the ancients did so by a process of hammering. This operation naturally produced a hardening, and it is likely that the renowned secret of Tubal Cain was not so much in his head as in his strong right arm. Spear-heads, daggers, arrow-heads, chisels, drills, knives and all implements demanding a sharp edge or point for cutting or piercing other objects, were hammered into shape and along the edge or point there resulted an excessive hardness, because of this prolonged cold-working. Many old relics have revealed this condition upon close examination.

As previously noted, an increase in

hardness is likely to be attended by an increase in brittleness, and this is especially true of copper hardened by excessive hammering or cold-working. Probably in some entirely accidental manner it was discovered that this overstrained state could be partially relieved by a reheating of the metal, and a primitive sort of annealing may have become a common practice.

Possibly even in olden times a certain amount of heat treatment, followed by quenching in water and other liquids, also came into general use. To such processes the word tempering has been rather loosely applied. This term should not, however, be confused with hardening, because the so-called tempering of copper may involve a softening of the metal. Nevertheless, the words hardening and tempering often appear interchangeably in the claims of modern rediscoverers of the lost secret.

The second general method of hardening copper was based on the fact that only the very pure metal is really soft. Almost any impurity that might have gotten into an ancient copper would have hardened it. The oxide of copper is particularly effective in this respect and in the first smelters, copper oxide had a good chance to get into the metal product. Once more the old familiar difficulty interferes. Many inventors have had their hopes raised high upon securing a copper which was undeniably hard, but which contained so much oxide that it was as brittle as glass.

There are elements which do increase the hardness of copper without intensifying the brittleness. Probably the first satisfactory combination produced was the alloy known as bronze and it was superior to ordinary copper in so many ways that an Age of Bronze gradually evolved. A simple bronze alloy is a union of copper and tin, and once again it seems likely that it was a freak of fate, the smelting together of ores containing both elements, that produced this new advance. An alloy of copper and zinc, which came to be called brass, was the product of another fortunate mixture. The historians of those early times so confused the terms applied to copper, bronze and brass, that it is now almost impossible in many cases to tell precisely which one the author had in mind. At any rate, for many generations copper, by itself or in combination with other elements, was the key metal in all the great states then rising to power. It was not until the advantageous qualities of iron and its alloys were fully realized that another inevitable change came to pass.

Copper did not yield its place without a struggle. The change came about ever so gradually, and there were countless individuals in those forgotten days who never really got accustomed to the new-fangled instruments. There were many who stood firm in their belief that the old ways were best.

The most stubborn resistance to the new deal in metals was displayed among those who conducted religious ceremonies. It is recorded that by the old Roman Law of Numa there were numerous restrictions upon the use of iron in any sacred relation. The garments of the priestly *flamines* were fastened with bronze brooches and they were directed to have their hair cut with bronze scissors, being expressly forbidden to employ instruments made of iron. In founding their cities, a furrow was traced with a bronze ploughshare. Bronze sickles were used to cut magical herbs. Tools brought into holy places to cut inscriptions had to be made of bronze.

As it came to be recognized that iron was much more efficient than bronze for cutting inscriptions, as shown by experiments in non-holy places, some concessions became necessary. For a time it was permissible to bring iron tools into holy places, provided an expiatory sacri-

fice accompanied them. Before long the practice had to be winked at and finally ignored altogether.

The point has been elaborated in some detail because it suggests the nature of the flaw in claims involving rediscoveries of lost arts. The ancients reluctantly gave up their instruments of copper, despite long-established customs, traditions and prejudices. Romantic lost secrets can not account for the great revolution.

It was the same sort of change as that in which copper itself had terminated the old Stone Age long before. Copper tools lost out in a competition with something better.

On a drowsy summer evening, August 8, 1921, in the front office of the *Pittsburgh Gazette Times*, the writer was at his desk behind the counter, with little to do but watch the clock and wait for the midnight relief. The early editions of the paper dated August 9 carried a story which made a lasting impression on this particular young loafer. On page one, with big black headlines, there was spread the story of Walter Bunton, who had "modestly admitted" that he stood on the threshold of fame and fortune. He had just rediscovered the lost art of hardening copper, a secret which had been hidden since ancient times.

Headlines, pictures, editorials, interviews, denials, speculations—the newspapers, especially those of the Middle West, had a field day.

It seems that Walter Bunton was a young man aged about 27, living in La Porte, Indiana, and employed as a machinist with the New York Blower Corporation of that city. He claimed to have been experimenting with the idea of hardening or tempering copper for several months without getting any results. Then one night he had a "sudden inspiration." The new idea was tried out and success crowned his efforts.

Another widely published version of the events leading up to the discovery was that Bunton happened to find some pages torn from an old encyclopedia, "lying on a trash pile ready for the match." A picture caught his eye and then he chanced to see an article about "an old Roman metallurgist, incidentally a murderer of renown, who knew how to temper copper." Thus it came about that Walter Bunton, "untrained in great universities, not the product of great laboratories, not a skilled chemist or metallurgist," was led to make the marvelous discovery.

The sequence of events, both real and imaginary, was certainly not clear to the reporters, perhaps not even to the inventor himself. At any rate, Bunton maintained that he had been lured to Gary, Indiana, on August 2, by a gentleman named Carl Miller, of St. Louis. Miller was said to have escorted Bunton to a luxurious office near the United States Steel Company plant, where he was introduced to several officials, including Judge Gary himself. A demonstration of the hardened copper tools easily proved them to be all that was claimed.

"'Name your terms,' said Judge Gary." ("Nothing indecisive about Gary," commented the *La Porte Herald*.)

"'One million dollars and two cents a pound royalty,'" said Bunton. (Walter was also in pretty good form).

And so it was arranged that Bunton was to get some hard cash for his hard copper, although no money was to change hands for two or three months, until the discovery had "gone the rounds of the foreign patent offices." In the meantime he was not at liberty to divulge the secret of his process, which was understood to be some sort of "heat and acid treatment."

The story broke in the newspapers and Judge Gary immediately denied everything. It then occurred to Bunton that

he must have been duped by a gang of crooks and he was very glad that he had not given them "the formula and process."

Letters and telegrams poured into La Porte. A wire from Winthrop Smith and Company of New York offered Bunton two million dollars and four cents a pound royalty. He stood ready to board a train for the metropolis, but his attorney could not locate the optimistic organization responsible for this philanthropic proposal. Manufacturing concerns "deluged" him with "alluring" offers. A mysterious Japanese in Chicago was eager to put the inventor in touch with Japanese government officials. On this issue Bunton was adamant; " 'the discovery must bring the most good to America,' " he declared.

A few of the letters Bunton received were congratulatory, some of them were of a begging nature, and many were from women who were enthusiastic about sharing the wealth with him; object mat., as the want ads in the personal columns so charmingly put it. In the end, however, Bunton remained true to his Michigan City sweetheart.

Unquestionably the *Gary Post* was a little harsh in its statement that "Bunton is either seeking notoriety or is loose in his upper story." But the fact remains that he was woefully shy of specimens and documents to support his assertions. Bunton could not seem to locate the important letter which led to the Gary excursion and that did annoy him very much. It is fitting that this brief review of the incident be closed with a revealing sentence which appeared in the *La Porte Herald*. "The last time he remembers having the letter, he said, was when he had it in his coat pocket on a trip down town to locate a reporter."

While the more sensational stories about hard copper have been featured in the daily newspapers, the technical journals have had a fine time arguing the matter pro and con, with the emphasis on the con. The names appearing in these accounts represent all degrees of scientific attainment up to and including that of Michael Faraday.

Many years ago, in the course of his researches on metallic alloys suitable for cutlery, Faraday produced a copper that was uncommonly hard. It took as keen an edge as anything found among ancient relics. A razor made of this copper proved to be quite serviceable and, really, there were but two considerations which tended to discourage further developments. In the first place the alloy was inferior to finely tempered steel and in the second place it was more expensive.

At one time a manufacturing concern called the Eureka Tempered Copper Company, of North East, Pennsylvania, was producing a copper said to be hardened by a secret process. Almer Thomas and Luzerne Merket were the names of the gentlemen to whom the discoveries were attributed. Their claims were investigated in 1890 by a subcommittee of the Committee on Science and the Arts for the Franklin Institute of Philadelphia. A few chemical and physical tests were applied to the metal, but the most interesting feature of the report given to the institute involves the questionnaires ("circulars" in those days) sent out by the committee to 100 establishments supposed to be using the Eureka hardened copper. The returns may be tabulated as follows: 5 "unable to see any difference"; 6 "claims—not substantiated"; 8 "tried for certain purposes—evidently was unfit"; 34 "highly favorable"; 47 apparently made no reply. This array of figures convinced the committee and it was recommended that the Franklin Institute award to the inventors its John Scott Legacy Medal and Premium.

The name of S. R. Dawson was for some years the center of an important

hard copper controversy, because this gentleman made repeated attempts to popularize his products. The late William H. Bassett, formerly director of research and metallurgist for the American Brass Company, told the writer that the activities of Mr. Dawson extended from about 1911 to 1922, and possibly over an even longer period.

An article published in *The Metal Industry* in 1916 stated that the Dawson process was "the secret of the inventor," but that "after the metal has been once treated by him it may be transported anywhere and remelted any number of times without a change in its quality." Whatever the secret process may have been, concealing the chemical composition was another matter and Mr. Bassett is authority for the statement that the copper contained from 17 to 18 per cent. of tin and about one half per cent of nickel, which gave the alloy its fine-grained structure.

The Dawson Hardened Copper was recommended for high-speed journal bearings, marine engines, trolley-wheels, watch springs, phonograph needles, locomotive links and link blocks, but it did not dodge the issue of cutting hardness. In fact it was in the realm of shears, razors, surgical instruments and cutlery in general that Mr. Dawson exerted his greatest efforts. It was argued that these copper implements were resistant to fruit acids, antiseptic solutions and all ordinary agents of corrosion. Circulars accompanying the tools described how they could be made to take and hold a keener and finer edge than steel, "if sharpened as directed on the reverse side hereof." Mr. Dawson appears to have believed in his products, always using scissors made of copper and shaving himself with a copper razor.

At one time Mr. Dawson maintained an office on Vanderbilt Avenue in New York City, but his persistent efforts to engineer this particular type of comeback for copper were not destined to meet with any great success.

On July 6, 1924, another one of the more spectacular hard copper stories hit the front pages of the newspapers. As the dispatches to the *Pittsburgh Gazette Times* (where the writer was again on the job to note and remember) expressed it, "what scientific men have been trying to do for 2,000 years . . . an obscure mechanic of little education and scientific knowledge is said to have done in a brief period of a month of experimenting."

The discoverer was James Earl Cummings, of East St. Louis. He had been cleaning the copper gaskets for his car, "a low priced machine of long service and worn aspect." While dipping the gaskets in a "chemical mixture" he was surprised to find that one of them would always spring back to its bent form whenever he tried to straighten it out. Mr. Cummings happened to describe his experience to some of the boys and one of them immediately exclaimed, " 'Jim, if that's true, your fortune is made.' " Jim decided to do some experimenting and to patent his formula.

A copper company invited him to Detroit and he had no trouble convincing them with a few simple tests. On July 5 he admitted to reporters that he had received a check for $1,500,000 and expected a royalty on every 100 pounds of copper produced. An article in the *New York Times* told of his being besieged by salesmen of bonds, stocks, insurance, homes and cars. Mr. Cummings, however, informed reporters that, " 'I don't reckon I will buy a car for a while. No, I shall keep the old car. It's good enough for us. And anyway, the car is responsible for my good fortune.' "

When he was telling about being "knocked cold" by the "cool million and a half" check, he made another remark

which rather neatly summarizes the East St. Louis incident. "'It's all like a dream, really,'" said James Earl Cummings.

A year later the old, old story was coming from Lorain, Ohio. A Negro labor foreman, E. E. Harrison, had devised a secret process for hardening copper by heating the metal in a vacuum. The usual reference to the ancient Egyptians was strangely missing from these reports, but otherwise they ran true to form. A new peak price of *three million dollars* figured in the offer of the old reliable "Eastern capitalists." The inventor's attorney, Victor J. Evans, of Washington, flatly refused to accept the sum offered by the greedy interests.

Perhaps Mr. Evans was doing what he thought was best for his client, but it would have been much nicer if he had permitted Mr. Harrison to do his own refusing. After all it is not every day that one has the opportunity to turn down three million dollars.

Newspaper editors seem to have become a little more suspicious of hard copper claims. Not so many of the stories about rediscovered lost arts—tales so closely akin to those renowned, ever-recurring, half-legendary dispatches in which Alexander Woollcott delights—have been able to break into the public prints of late. It would be a pity if they were to disappear altogether. It is a fascinating study, as Mr. Woollcott has pointed out, to note the peculiar twists and turns these stories exhibit, especially in their minor details.

Thus it is a real disappointment to find that in its edition of April 16, 1929, the *New York Times* must squeeze into a few lines on page 13 the exciting report that John Cameron, mechanic, and Hugh Webster, bank clerk, of London, Ontario, have accidentally "discovered the art of tempering copper" which will "revolutionize the use of copper in industry."

Or again, buried in the March 12, 1934, issue of the *Indianapolis Star*, one may find the item of only nine lines which tells of Riley Jones, of Chippewa Falls, Wisconsin, who has perfected a razor of "copper unmixed with an alloy" which has been "tempered to the hardness of steel" in his little home workshop.

There have been many others in the past and there will be many more in the future. Another big story for the front pages is just about due.

The search goes on. Only a fool would dare to be dogmatic about what can or can not be done.

It is the generally accepted opinion that the ancients did indeed know how to harden their copper. But the methods they used are still available, and painstaking research has produced some copper alloys which have a hardness exceeding that of any copper relics known to have been made in olden times.

One may read in technical journals the long record of advances in the development of more efficient copper alloys. Harrison E. Howe, editor of *Industrial and Engineering Chemistry*, recently showed the writer an alloy of copper and beryllium which was hard enough to cut mild steel. Many combinations have been tried and will be tried in the effort to secure greater hardness without sacrificing the unusual toughness and durability of the metal.

Some time, perhaps, the magic method will be found. The old red metal may once more compose the tools which will carve the steps of progress to a new and better age.

SOME RACE PROBLEMS IN SOUTH AFRICA

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Introduction

Race problems in the sub-continent of South Africa, from the point of view of the admixture that has gone on there in the past and that is going on there more and more, have hardly been reported upon from a broad, basic aspect. This is perhaps to be regretted, because in that sub-continent the white man (whether of British or Dutch ancestry) is living amidst a negroid population about four times as numerous as his own. Will the white race maintain itself and keep relatively pure, or will it be swamped in miscegenation, with a resulting mongrel population of somewhat brown color? There are different views on the answers to these questions, and I have heard both questions answered in the affirmative in South Africa, though laws are now being enforced against miscegenation between white and black.

In order to indicate the major impacts of the whites on the natives in various parts of South Africa, the following events are significant. The Cape of Good Hope was discovered by Bartholomew Diaz in 1486, while a little later in 1497 Vasco da Gama rounded the Cape and sailed on and named Natal. Saldanha discovered Table Bay in 1503. English ships first visited Table Bay in 1591, while the first Dutch fleet appeared in South African waters soon after in 1595. In 1620, the Cape was annexed by the English in the name of King James I, but was not garrisoned. The Dutch East India Company sent out van Riebeeck in 1652, and a settlement at Cape Town began. Cape Colony was first surrendered to the English in 1795, while Grahamstown in Eastern Cape Colony was founded in 1812 and Port Elizabeth in 1820. It was in 1835 that Durban was founded.

It may be mentioned that the officially estimated mean population of the Union of South Africa for 1933 was 8,369,200 persons, comprising 1,889,500 Europeans; 5,681,100 Bantu; 196,400 Asiatics, over 80 per cent. of whom are in Natal; and 602,200 Colored persons, 90 per cent. of whom are in the Cape Province. If Rhodesia and South West Africa are included, the proportion of natives to whites is increased.

Remarks on the Native Races

There are three principal elements in the South African native population, namely, the Bushman, the Hottentot and the Bantu, the sequence of their arrival in South Africa being in the order indicated.

The Bushmen are a primitive people, short of stature, slim, muddy yellow in color, with small tufts of rusty brown, woolly hair, giving a peppercorn appearance. Their skin is greatly wrinkled. They have low foreheads, prominent cheekbones, small, sunken eyes and ears with very little trace of lobes. Their noses are small, flat and broad. Their jaws project only a little. They have hollow backs due to inward lumbosacral curvature, making the buttocks appear prominent. They are wandering hunters who use bows and poisoned arrows, do not build huts, are independent and are users of an isolating, non-inflexional language with characteristic clicks. They are makers of rock paintings.

The Hottentots are of medium stature and slight build, with small hands and feet. They are reddish-yellow in color, with narrow heads, black woolly hair,

high cheekbones, hollow cheeks, pointed chins, eyes far apart, ears with moderately developed lobes and broad, flat noses. A fair degree of prognathism is present. There is marked lumbosacral curvature and characteristic steatopygia. They are nomadic pastoral people who build beehive huts grouped in kraals, have tribal organizations and use an Hamitic inflexional language, also rich in clicks.

The Bantu represent the greatest number of natives. They are a dark-skinned negroid race, but browner than the Negro. They are well built and many tribes are rather tall. Their hair is black, rather short and crimpy or woolly. They have full cheeks, large prominent eyes, thick lips, platyrrhine noses and prognathous jaws. Their hands and feet are large. The Bantu came in waves from the north, where there had been an infusion into their negroid stock of Semitic and Hamitic blood from contiguous tribes. They were rather warlike stocks, who sent out raiding parties to rob other tribes of their cattle, the latter being of great importance to them. They build kraals, often of considerable size. Their languages are formative and inflexional, with many linguistic groups and tribal dialects.

It is not within the purview of this paper to discuss at length the very difficult and conflicting accounts of the early native races of South Africa, complicated by waves of immigration, racial differences and intertribal wars, but only to give a background indicating how the present native tribes[1] have come to be in South Africa, their varying geographical distribution (see map) and their miscegenations.

The Bushmen occupied most of the mountainous districts in the earliest days of South African history. To-day, they are chiefly in the Kalahari and South West Africa. Using bows and arrows, they were more than a match for the pastoral Hottentots, who were numerically stronger, and ultimately the Bushmen were driven away by the whites and the Bantu.

The Hottentots, known to Arabian geographers in the tenth century as Wakwaks or Wa-Khoikhoi, were at that time south of Sofala on the East Coast of Africa. Another group of Hottentots was found near Benguella on the West Coast in 1667. There may thus have been two streams of these immigrants from the north. When the Dutch settled at the Cape, the Hottentots were not known to range beyond the Orange River. In the sixteenth and seventeenth centuries they had inhabited the valleys of the Karroo rivers. Now the two chief sections of the Hottentots, the Korana and the Namaqua or Naman, are largely in the western part of Southern Africa, but a large number of subtribes were recorded in the early days of white colonization. It may be mentioned that the Bushmen were sometimes termed Mountain Hottentots by some of the early observers. There were numerous migrations of the Hottentots northwards and northwestwards as European occupation increased, some tribes dying out and others amalgamating with other tribes in the process.

It may be remarked that some authorities consider that the Bushmen and Hottentots belong to a common Bush race, because of certain physical resemblances between them. There are few pure specimens of either race now-a-days. That Hottentots are crosses between Bushmen and Bantu can now hardly be sustained, but it has been suggested that Hottentots may have originated in the past by the crossing of Bushmen with some northern Hamitic negroid race before the Hottentots migrated.

The Bantu, the present dominant native race in South Africa, arrived there in a series of waves of invasion from the north, perhaps from East Central Africa. There is no doubt of

[1] Many variations in orthography of names of tribes occur.

their northern origin. In the eighth century, the Bantu were known to Arab and Persian traders on the East Coast under the names of Kafir (infidel) or Zeng (black). Probably at this time they were living in the area now known as Northern Rhodesia. As recorded by El Masudi in the tenth century, the Bantu tribes were known to be around Sofala, having crossed the Zambesi but not the Sabi River. The Hottentots or Wakwaks were then to the south of them.

Apparently there were three main streams of Bantu migrating southwards by the west coast, the east coast and more or less central routes, conquering and mixing with their predecessors as they went.

The Bantu migrating by the western route became known as the Hereros. They settled south of the Cunene River and around Lake Ngami and extended to the Atlantic. They included the modern Ovambos or Ambos and sub-tribes. Under European rule, especially during the German domination in South West Africa, some became scattered and a few entered the Waterberg district of the Transvaal.

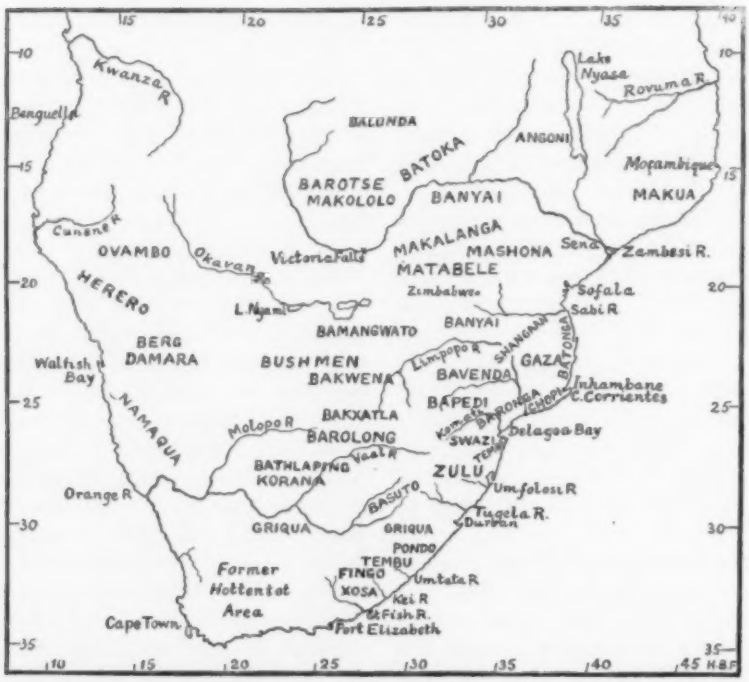
The most important streams of migration were those by the East Coast. Of these, four linguistic groups of Bantu can be distinguished, and these seem to correspond to some extent with waves of invasion. These four groups are the Makalanga and the Bechwana traveling inland and more central, and the Bathonga or Baronga and the Zulu-Xosa or Zulu-Kafir along the coast. The Bechwana and the Zulu-Kafir are especially important. For convenience each of these groups may be considered separately. Their later distributions are indicated on the map.

The Makalanga group includes a series of tribes such as the MaKalanga in the west, the BaNyai in the north and the Mashona in the east of Southern Rhodesia. In the sixteenth century the chief of the Makalanga was known as the Monomotapa, who ruled over a great empire in what is now Rhodesia. His subjects raided south to the Matopos. The Mashonas in the past occupied the Sena district and have now moved south. The BaNyai occupied the south bank of the bend of the Zambesi and some have migrated south.

The BaRotse and BaLundi crossed the Zambesi at different periods during the eighteenth century. The BaRotse are now the dominant tribe on the Upper Zambesi in Northern Rhodesia and, according to Coillard, came from the east and claim kinship with the BaNyai. Early in the nineteenth century, the BaRotse were subdued by the MaKololo, a section of the Basuto, who are members of the Bechwana group. The BaRotse successfully revolted against the MaKololo in 1865. The BaToka of the middle Zambesi basin probably belong to the Makalanga group.

Here may be mentioned the BaVenda, a composite group of tribes, who now occupy the northeastern part of the Zoutpansberg district in the Northern Transvaal, having conquered and absorbed its previous inhabitants. They left Mashonaland perhaps about the end of the seventeenth century and have a definite Makalanga strain in them as well as some Bechwana.

The Bechwana group comprises a series of tribes, whose language is different in pronunciation from other Bantu languages, but among the tribes there is similarity of both language and customs, the name Bechwana meaning "the people who are alike." The pioneers among them were the BaLala and BaKalahari. They penetrated south and, mixing with the Bushmen, came to live near Potchefstroom. Other Bechwana tribes penetrated to the neighborhood of Rustenburg; others settled around Kuruman. The BaThlaping went further and represent the southernmost advance of the Bechwana, having reached the Lange-



MAP SHOWING APPROXIMATE DISPOSITION OF CERTAIN AFRICAN NATIVE TRIBES AFTER THE ZULU CONQUESTS. CIRCA, 1840.

bergen, a region west of the junction of the Vaal and Orange Rivers. They have intermarried with the Koranas.

The BaRolong formed the next wave of invasion, became important but subsequently broke up into a number of tribes, some of whom had constant feuds with the Basutos under Moshesh. The BaMangwato are a branch of the Ba-Rolong, who settled and remained on what is now known as Khama's country in the Bechwanaland Protectorate.

Another important clan, the Ba-Kwena, gradually passed into the Northern Transvaal. They became involved in internecine warfare and split up. Some passed southward and settled on the Caledon River and surrounding areas, forming the Basutos of modern Basutoland. As already noted, a section of the Basutos, the MaKololo, went north into Barotseland. The Ba-Kxatla settled near Mochudi in Bechwanaland and later were known as Linchwe's tribe. The BaPedi are Sekukuni's people in the Transvaal. There are other Bechwana tribes which need not be considered here.

The AmaThonga, BaThonga or Ba-Ronga group comprises tribes who speak dialects of a language called Thonga or Tonga. These tribes were migrants from various regions, driving out and absorbing the previous occupants. The Ba-Tonga were known to be occupying the district between the Sabi and Inhambane Rivers in the sixteenth and seventeenth centuries, and attempts were made to establish Christian missions among them about 1560. Another division is the BaChopi, who still occupy the country between Cape Corrientes and the Limpopo. Another tribe is the Tembe with several offshoots in the Komati River basin and a little south, speaking the Si-Ronga dialect. The Tembe are said to be of Kalanga extraction. There has been much raiding

and intermixing, and the people of the Thonga group now form the natives of the areas of Inhambane and Lourenço Marques (Delagoa Bay) in Portuguese East Africa. Some of them were raided by the Zulus and fled from Natal over the Lebombo Mountains into the Lydenburg district of the Transvaal. The so-called Shangaans, who have much Zulu admixture, speak Transvaal Thonga.

The great Zulu-Xosa or Zulu-Kafir group was reported to have been near Sofala in the tenth century and was definitely further south in 1553, when wrecked seamen found the region between the Umfolosi and the Umtata Rivers occupied by Bantu tribes, probably Zulu-Xosa or their Xosa division, whose speech was different from Tonga.

The AmaXosa, AmaPondo, AmaTembu and AmaPondumise (generally referred to as Xosa, Pondo, etc.) are tribes whose first chiefs had a common ancestor. They were the first wave of the Zulu-Xosa invasion along the East Coast and advanced as far as the Great Fish River, encountering Hottentots on the way. They fought nine Kafir wars against the whites between 1779 and 1877. Many of them still live in the Transkei, a native reserve.

The Great Abambo group of tribes occupied Natal in the seventeenth century. Some 95 of them were known about one hundred years ago. There are somewhat divergent accounts of the relationships between the tribes and the sanguinary conflicts that occurred among them at the beginning of the nineteenth century. One warrior tribe in Natal was the Vatwah or Endwandwe; another was the Mtetwa, of which the Zulus were a section. The Zulus became a great raiding people under their chiefs Tshaka and Dingaan. Tshaka had a great capacity for wise leadership and built up the Zulus into a formidable warrior nation by rigorous selection and discipline. The Zulus under Tshaka from 1818 to 1828 maintained a reign of terror. Resultant on Zulu raids, some Abambo tribes fled and united as Swazis; the Vatwah, driven north beyond the Zambesi, became Angoni; others became Gazas, had internecine strife and one section became the Shangaans, who mixed with the Thongas. Some Vatwah joined revolters against Tshaka, they united as Ma-Tebele, ravaged the Transvaal, annexed Monomotapa and became the foe of the Mashona. In 1828 Tshaka was killed by Dingaan, who massacred some Dutch trekkers or emigrants in 1838, was then defeated by the Dutch, fled to and was killed by the Swazis. The Zulus were subdued by the British in 1879. Five other large Abambo tribes, defeated by the Zulus, fled south and fought Xosa, Tembu and Pondos, all the defeated parties, with remnants of other tribes, becoming Fingoes, that is, destitute, who were ultimately protected by the British.

Native Hybrids

It will be realized that, while in the course of time, many of the tribes living in South Africa have become more or less consolidated, yet in practically all of them intertribal admixture has taken place in the past. Tribal wars of conquest were usually concluded by the conquerors killing all the male vanquished and absorbing the conquered women into their own tribes. While a general racial type may have been perpetuated, yet differences occur among its components and at the present time, numbers of natives, especially in the Cape Province, have little idea of their true tribal origin. Tribal crossing by intermarriage has further complicated the native race problem.

Among hybrid people of mixed native origin a few examples may be given. The Korana are Hottentots with some Bushman admixture. The Berg Damara, who speak a Hottentot language, are early Bantus with Bushman and Hottentot blood. The BaTamaha, near

Potchefstroom, are a mixed tribe of Ba-Lala and Bushman origin. The Ma-Sarwa or Vaalpens, hybrids of Bushmen and BaKalahari, are the cattle herds of the BaMangwato. The BaThlaping are a Bechwana stock who married Korana wives and in such crosses the Bushman and Hottentot (or Bush) characters are dominant to the Bantu. In the Lydenburg district the Amabae (BaMbayi) have resulted from intermarriage between Basutos, Thongas and Swazis. The Tambuki are hybrid Bushman and Tembu.

Undoubted "ethnic melting pot" areas occur in South Africa. Among these may be mentioned the Kalahari, where Bushman-Hottentot admixtures have been impinged on by Hereros from the north and by Bechwana on the east. Another area of hybridization is around the junction of the Vaal and Orange Rivers as far as the Nokana River on the west and Kuruman and Taungs in the north, where Bushmen, Korana Hottentots and Bechwana, like the Ba-Thlaping, come together. Yet another is the area of the Northeastern Transvaal extending into Portuguese East Africa, where BaVenda, BaPedi, Thonga and Zulu admixtures have occurred.

Under British and South African rule, tribal wars have ceased—sporadic quarrels among small clans only occur nowadays, and these are unaccompanied by conquest and absorption. Urbanization of natives in South Africa, particularly of the men, who go to the towns as domestic servants, employees in manual work in shops and building trades and as laborers on the gold, diamond and other mines, is playing a great part in breaking down tribal distinctions and intertribal prejudices.

The White Population of South Africa

The white population of South Africa is composed of a number of elements, and a white problem may be said to exist there. However, the very heterogeneous assemblage of representatives of Europeans settled in South Africa seems to show signs of blending into a more or less homogeneous congeries under the name of South Africans. Among the younger generation quite a number are unaware of the place of origin of their ancestors, and first express surprise at the inquiries and then interest when told of the etymological significance of their family names.

The predominant elements in the white population are the British and the Dutch, who together form the bulk of that population. The early Portuguese navigators did not settle permanently. It was in 1652 when the Dutch leader, J. van Riebeeck, arrived that settlement began. The Dutch began to import slave labor, largely from the Dutch East Indies, in 1658, while they also utilized the Hottentots as servants. A number of French and Belgian Huguenots arrived in 1688, but their language was soon suppressed and they became absorbed into the Dutch population. The Huguenots introduced wine-making, the Dutch having already introduced viticulture. There have been repeated struggles for supremacy between the British and Dutch since about the end of the eighteenth century, resulting in sundry northward and northwestward migrations of the latter (especially the Great Trek of 1836) and the formation of republics in the Transvaal and Orange Free State about the middle of the nineteenth century. British settlers came to the Eastern Cape and to Natal early in the nineteenth century. The Cape Province, with its increasing numbers of annexed Native Territories, continued under British government. After the Anglo-Boer War of 1899 to 1902, the Republics became British territory and in 1910 the Union of South Africa was created. Racial feeling between the British and Dutch was fomented by some diehards, but

most of the great leaders, including Botha and Smuts, loyally kept their oaths of allegiance and endeavored to allay racial feeling. To-day, among young South Africans, intermarriage of Dutch and British in many cases is taken as a matter of course, without regard to nationality. The contracting parties, though of different stocks, think nothing of this—they are South Africans. Where children of British-Dutch ancestry have grown up, it has been of interest to note the great influence of the mother and the mother's nation on them. In many cases, if they express sympathy at all, it is with their mother's people and their ideals.

In addition to the Huguenot element in the Western Cape, mention must be made of a strong German element in parts of the Central and Eastern Cape (then British Kaffraria) due to settlements of Germans as colonists about the middle of the nineteenth century.

For the last two generations, many admixtures of European peoples have occurred in South Africa. Predominantly there is the British-Dutch cross. In addition, there are other crosses involving members of practically all European nations. The groups of such European admixtures may be small, but they act as a leaven in the community.

With the development of diamond mining (after 1867) and of gold mining (especially after 1886), men and women of many nationalities found their way to the diamond fields and to the gold mines. As in every mining camp, a heterogeneous European population was soon reinforced by native laborers and then penetrated by traders, many of whom were Russian and German Jews.

Emigration from Central Europe and from the Baltic areas has recently added a number of races to the European population. Such emigrants include Lithuanians, Latvians and Esthonians, many being of the Jewish faith.

One sad feature in South Africa is the existence there of the class known as "poor whites," not well enough equipped mentally for skilled work and, though often physically fit, with no unskilled labor which they can do, because unskilled labor is performed by natives and not by whites. Many circumstances have contributed to the making of the "poor white" class. These can not be dealt with in any detail. It must suffice to mention the effect of Roman-Dutch law on land subdivision, isolation of small settlements, intermarriage with near relatives and with Cape Colored (Eurafrican) people, successions of droughts and bad seasons, increase in feeblemindedness due to inbreeding and isolation, and also ingrained laziness (due to their dependence on natives to do all the hard work), which now has become second nature. Unfortunately, the "poor whites," of whom the vast majority are of Dutch stock, are very prolific and their children have a similar mentality to themselves. It has been estimated that up to 150,000 "poor whites," forming about 8 per cent. of the total white population, are in South Africa.

Eurafrican Admixtures

Problems created by hybridization between whites and natives have to be considered. An Eurafrican race, generally designated as Cape Colored, is found chiefly in the Cape Province. At present these Cape Colored people are about equal in number to one third of the white population of the Union of South Africa. Hottentot women taken into the families of early white colonists, their Malay servants and slaves and Kafir women of various tribes who became servants, mainly constituted the Cape Colored progenitors. In the Western Cape it would seem that Hottentot women were the usual ancestresses, and in the Eastern Cape Province, Xosa, Tembu and Fingo women intermarried with many types of European males.

In other parts of the country other native women were concerned. Eurafrican admixtures were also perpetuated in the early days of colonization by misguided European missionaries who hoped thereby to win converts, and by visiting traders who wished to increase barter. More recently, small storekeepers and pedlers on trading circuits have added to the Colored population by miscegenation, and more casual visitors, such as come into ports, have contributed to a slight extent.

So far as European women are concerned, few white women in the past married with native men, and only did so if in dire distress, as in the case of destitute widows with young families for which no white man would take the responsibility; such unions are not now allowed. Marriages between European women and Colored men also are not common.

Some hybrid Colored people form distinct groups. Thus, the Griquas arose from matings between early Dutch colonists and Hottentot and Bush women. The Rehoboth Bastards are also hybrids between Boers and Hottentot women; they trekked north into South West Africa. Roving whites, such as Coenraad Buys at the end of the eighteenth century, mated with native women and raised numerous progeny who formed groups in various parts of the country.

From 1917 I have had the opportunity of investigating a number of newer cases of Eurafrican admixture as well as of Asiatic intermarriages with native and Colored peoples, several generations being studied, and as many members as possible of the families being considered from their physical, mental and social aspects. Unfortunately, photographs usually could not be obtained, owing to strong objections by some of the parties concerned.

One example of relatively simple miscegenation may be given in some detail. A fair-haired, blue-eyed Belgian married a Zulu woman. They had eight children. The actual proportions of white and native blood in the descendants are indicated in the upper portion of Fig. 1. However, the members of the family classify themselves, approximately correctly, as white, black and brown. These grades are based on skin color, as is indicated in the lower portion of Fig. 1. Thus, the eldest daughter is very dark and described herself as "a proper black woman like my mother." She dislikes the brown members of the family, referring to them as "trash."

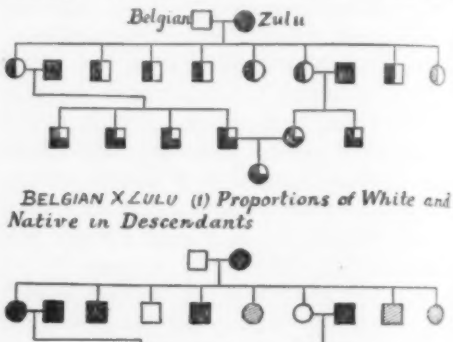


FIG. 1

The second member is a very dark man. The third, a man, is "white" and is much disliked and despised by the rest. The fourth is a black man, the fifth, a woman, is brown. The sixth, a woman, is "white," while the seventh, a man, and the eighth, a woman, are brown.

The very dark eldest daughter of the F_1 generation is married to a pure Natal Zulu. They have a family of four sons, two described as black and two as brown. The "white" woman of the F_1 generation married a Zulu and has one black son and one "white" daughter. Intermarriage has occurred in the F_2 generation, the last-mentioned white daughter having married the younger black son of the eldest daughter of the

F_1 generation. They have one brown baby daughter.

Of the fifteen descendants of the original couple, six approximate to the Zulu type (black), three to the European (white), while six show intermediate skin color (brown). Socially, the white members are not popular with their Colored brethren, while the brown members appear to be despised by "white" and black alike.

A more complicated admixture, not easily charted, as details of some "in-laws" are lacking, has come from marriages between three families, each of mixed origin. These families may be designated A, B and C.

Family A was founded by a Dutch man and a Malay woman, who might have had some white blood. Of their family one son and his descendants are known. This son married a Colored wife. They had three children. The first was a daughter described as "white"; the second, a son, was a Cape boy, with light skin, European features but pouting lips and colored whites to to his eyes; the third son, described as "Cape-Dutch," married a woman who in herself united families B and C. Their six children will be considered later.

Family B originated in a marriage between a Norwegian man and a Hottentot woman. They had one son, who married a Colored woman of Family C.

Family C had a male ancestor who was either German or Dutch and had a Dutch name. He married a Kimberley woman, described as "white with a dash of color," having a white skin and black hair but a flat nose. Of their family, one daughter married the son of Family B. They had one daughter, who married the younger son of the F_2 generation of Family A, their children forming the third filial generation.

The father of the third filial generation is of Dutch-Malay and Colored blood. His wife combines Norwegian, Hottentot, German or Dutch and some form of slightly colored ancestry. Their family consisted of six children, two of whom died before they were four years old. The eldest is a daughter, married to a Dutch man, who passes as white and has two children. The second is a son who looks white but calls himself Cape or Colored, has black hair and eyes but European skin color and appearance, shows slight pigmentation round his finger nails, has the "native" trick of rolling his eyes and is betrothed to a Cape girl. The third, a daughter, resembles her elder brother but has frizzy hair. She has married a Cape man. The fourth and fifth children, sons, died young. The sixth, a son, is much darker than his brother and has pouting lips and coffee-colored whites to his eyes. He calls himself a Cape boy.

Most members of the family seem pleasant, respectable, fairly well-to-do people, sharply divided among themselves on the question of color. In the third filial generation, the native color has become diluted and some of its members pass for whites.

Many other cases of racial admixture have been investigated by me, but space prevents their presentation here. Accounts of some have appeared in the *South African Journal of Science*, Vols. XXII, XXIV and XXVII, but many of the newer cases are not on record. An outline of some further Eurafrican crosses may now be given, the families being numbered.

(1) A Dutch man married a native woman of unknown tribe, probably Bantu. They had a son who married a Basuto. One of their daughters married a fair Scotsman, another a Zulu. One child of the Scottish marriage is married to a Cape Colored woman, the offspring of a Norwegian father and a Colored mother. Four generations of this family have been investigated. All grades of color are exhibited among its members and all types of opinion. Within the

family dissentient views on racial admixture occur, but it is evident that the European element has not improved from the admixture. The native element has gained to a slight extent, but the Cape Colored members are in an anomalous position. One satisfactory feature is that some of the Colored race realize their position and are openly advocating racial purity.

(2) Another family arose from Dutch-Xosa miscegenation, which has been repeated by a son, while other children have married with other Cape Colored folk. Two filial generations are known in some detail. Altogether, there were fifteen individuals who varied from almost black to two members who pass as white. Most of them are brown-skinned. Their lips show Bantu features mostly. The hair in this family varies from frizzy or crimpy Bantu to fairly straight. The "white" members of the family are somewhat temperamental compared with Europeans and, under stress of emotion, give vent to their feelings in violent, hysterical outbreaks.

(3) Another family originating in a Dutch-Xosa marriage has been investigated through three filial generations. Some of the results are shown in Fig. 2. The Dutch man may have had some admixture of Javanese blood. He married a Xosa slave girl. They had six children, of whom one man and one woman had light skins, and one man had dark and one man and two women olive-colored skins. Two men and two women had crimpy, native type of hair, and one man and one woman had straight hair. Two men and one woman had lips and nose of native type, the others had the European type of lips and nose. Of this generation, one dark man married a Xosa; they had three children, but nothing is known of them. One olive-skinned woman is married to a Dutch man. They had six children. Of the six members of this second filial generation, two women are "white," one man and one woman dark and two men olive-skinned. Three men have crimpy hair and three women slightly crimpy hair. Two are European and four native as regards lips and nose. One man of this generation is married to a thin-lipped Cape Colored woman and their children are typically Cape Colored. One woman is married to a Dutch man and their child is a masked white.

(4) A Dutch farmer married a typical Hottentot woman. They had two sons and three daughters. The eldest son married a Hottentot woman and had 14 children, of whom 9 are dead. One of his surviving sons married a cousin, who was the sole survivor of 10 children. These two have a family of three daughters, so far unmarried, who have olive skins, Hottentot hair and oval faces, with thin lips of European type. They also show slight steatopygia and two have high cheekbones. In the F_2 gen-

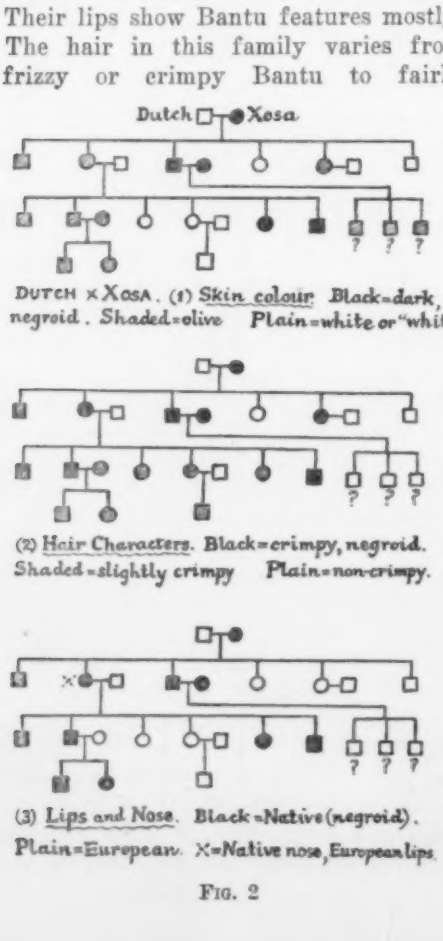

Dutch
Xosa
? ? ?
DUTCH × XOSA. (1) Skin colour. Black=dark, negroid. Shaded=olive. Plain=white or "white"
? ? ?
(2) Hair Characters. Black=crimpy, negroid. Shaded=slightly crimpy. Plain=non-crimpy.
×
? ? ?
(3) Lips and Nose. Black=Native (negroid). Plain=European. ×=Native nose, European lips.

FIG. 2

eration heavy mortality on both sides of the family is noticeable.

(5) A blue-eyed Danish sailor, employed in whaling, married a Xosa woman. They have two sons and a daughter. Their eldest dark-skinned son married a Cape Colored woman (origin uncertain), and they had three, not very bright, children. Of the younger son nothing is known. The daughter, olive-skinned and with European type of hair, is married to a Dutch man, their family consisting of two boys and one girl. One boy with blue eyes looks European, one boy has brown hair and negroid lips and the girl has flaxen hair and blue eyes but Bantu facies. These children are more intelligent than their cousins and they have more white blood.

(6) A German man, with hints of Colored blood, married a Hottentot woman. They have two sons and two daughters. One son and two daughters are largely of European appearance; the younger son resembles his mother but has a European type of nose. Of the daughters, one is married to a pure German and is in terror of her Colored blood becoming known. Their infant son is said to be like his father.

In this family, the first filial generation is physically weak and temperamentally unstable. The European influence is definite but varies in degree. The native influence is more obvious in the sons. There is antagonism between the whiter and less white members of the family, the former considering themselves white. The Hottentot mother is bitterly conscious of the position of some of her children. In her own words: "The whites look down on my family; the blacks spit at us; we are outcasts."

(7) An American Jew trader married a woman said to be a Basuto but having Pondo facial markings. Both were healthy. Their family consisted of four sons and five daughters, of whom three sons are dead. Four of the surviving children show Semitic characteristics, either in features, nose or hair. All are of poor physique, and intellectually none is well equipped. Syphilis of unknown origin has been contracted by two of them. Chest troubles are very marked in the family. Two (who are dark) are married, and the only child in each of the families is of poor physique.

(8) By intermarriage between members of two families, each of mixed origin, Portuguese, Dutch, Huguenot, Basuto and Javanese (Malay) blood is being combined. The characteristics of the families are summarized in Fig. 3. The founders of the first family were a Portuguese sailor and a Dutch woman from Java. One son married a Basuto and they have three children, one of whom, a man of weak physique and light brown complexion, married into the second Colored family. Of the daughters, one is Cape in appearance and married a Cape boy, the other is native in appearance. The second family was formed by a Huguenot who married a "Java slave girl." One of their sons married a Basuto. They had six

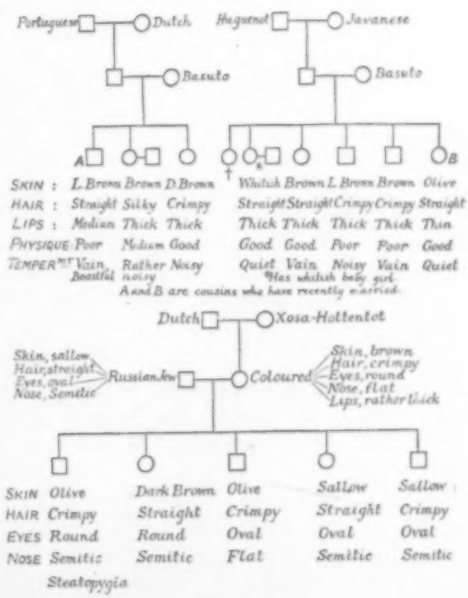


FIG. 3

children, one of whom is married to a Dutch man and has an infant girl, and one has recently married a man in the previous Colored family. One is dead, the others are unmarried.

In the second generation of the Portuguese-Dutch-Basuto family, the man shows the poor physique often seen in the European-Native cross, combined with great boastfulness. In the two women the native element appears to overshadow the European. In the Huguenot-Java-Basuto family, the men are also of poor physique and are unreliable and vain. The women consider themselves white and are light in color; their physique is superior to their brothers.

(9) The founder of this family was a Belgian Huguenot who married a Polish woman from Vilna. Of their children, one son went to South Africa and married the daughter of a Jewish trader and a Cape Colored woman (probably Dutch-Hottentot), their family being three sons and one daughter. Two sons are Jewish in appearance but with negroid lips, the daughter looks Syrian and is excitable. One son, of native appearance, has married a Basuto girl recently.

This family presents a curious admixture. The Belgian and Polish influence seems quite masked by Semitic and Hottentot admixture and, after the introduction of the native element, the progeny, especially the men, were of poor physique. Family pride and social ambition were noticeable, and the man who had a Basuto wife was despised by his relatives.

(10) A family that combines Jewish, Dutch, Xosa and Hottentot blood was initiated by a Russian Jew from Odessa who married or lived with a woman described by herself as a Bastard of mixed Dutch, Xosa and Hottentot blood. Five children have been born. Their characteristics are also shown in Fig. 3. The eldest boy shows steatopygia, indicating the Hottentot admixture of the past (his mother being heterozygous), his nose is Semitic, his eyes and hair of Xosa type, while his cheekbones are high like his mother. Another boy and two girls are of the Semitic type. The remaining child, a boy, is Cape Colored in appearance. Three of the children, all boys, have crimpy hair. The children did not show thick lips.

As in Family (7), the Jewish influence is very marked. In some parts of the Cape Province, for instance, in the neighborhoods of Port Elizabeth and Oudtshoorn, Cape Colored people with markedly Semitic cast of nose and countenance can often be seen. Europeans in these neighborhoods, intimately acquainted with local conditions, have expressed their opinion that these Hebrew-like Colored people "mark the path of the itinerant Semite pedlar," and there appears to be a good deal of evidence for this view.

Asiatics and Asiatic Admixtures in South Africa

Apart from the native and Colored elements in the population, other racial elements have been introduced in the past. As already stated, the Dutch East India Company used the Cape as a provisioning depot, and some of their European staff settled there. They brought with them their Malay servants (some Javanese), and their descendants still form a small separate group, the Cape Malay, living especially on the coast of the Cape Province, where they are expert fishermen, well known in Cape Town and Port Elizabeth.

The development of the diamond industry at Kimberley about 1867 led to the importation of Indian labor, chiefly from Madras. For the development of the sugar industry in Natal, Indian coolies, largely Tamil and Madrassi, were brought in as indentured laborers in 1860, native labor having proved not very satisfactory. Indian laborers also built the railway from the Point to Durban in 1860. The Indians liked the

country and remained there, the result being that much of the rich agriculture, including sugar, fruit and ginger, in the Garden Colony of Natal, is done by Indians to-day. These people, now about as numerous as the whites in Natal, form many small settlements, are thrifty and some employ natives to work for them. As Indian waiters and shopkeepers, particularly vegetable sellers, they have spread throughout the Cape, Natal and the Transvaal. A few wealthy Indian silk merchants have also settled in the country. At present, the government has arranged free repatriation of any Indians to India who so desire, but the conditions in South Africa are more attractive than those in India and but few avail themselves of it.

A short-lived experiment (1904–07) of the introduction of Chinese indentured labor on the gold mines of the Witwatersrand was a failure. Disease spread among them, quarrels and feuds occurred and the survivors were repatriated. Some Chinese are still present in South Africa, mostly engaged in growing vegetables, in laundry work and a few as shopkeepers and silk merchants. The presence of Asiatics in South Africa has led to various crosses with them, some of which may now be considered.

Afro-Asian admixtures form another group of the newer elements in South Africa, these including especially the progeny of unions between Indians and Kafirs, often due to insufficient numbers of Indian women compared with men. Such unions occur chiefly in Natal and a few in other parts of South Africa. Most of the Indians at present in Natal have been born in the country.

The characteristics of a family living near Durban, who combine Tamil (Indian) and Zulu blood, are given in Fig. 4. The father, a Tamil, born in Natal, is a tall, spare thin man, brownskinned, with oval features and eyes, thin lips and nose and straight hair. He is voluble and excitable. His wife, a Zulu, is well built, stout, blackskinned, with round features and eyes, thick lips and flat nose. She is of very equable temperament. They have three sons and three daughters. One son and two daughters resemble the father in brown skin color, two sons and one daughter are black like the mother. In this family the Bantu type of bodily build, hair, eyes and lips is dominant over the Indian, four of the six children showing such characteristics, but the distribution of the characteristics varies among the members. The children having native physical characteristics, however, are rather more refined in features than their mother, and the whole family is of better build than the father. In temperament the boys resemble the Indian father in being excitable, the girls are like the mother in being equable.

A number of other Indian-native and some Indian-Colored families are known

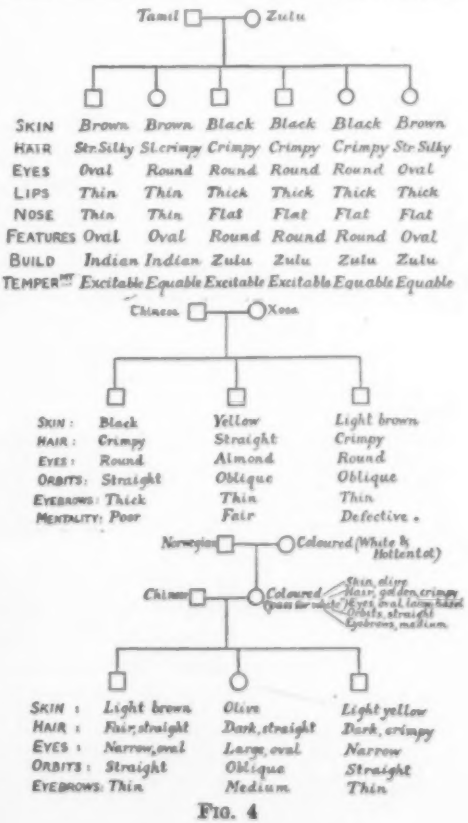

Tamil
Zulu
SKIN Brown Brown Black Black Black Brown
HAIR Str.Silky Sl.crimpy Crimpy Crimpy Crimpy Str.Silky
EYES Oval Round Round Round Round Oval
LIPS Thin Thin Thick Thick Thick Thick
NOSE Thin Thin Flat Flat Flat Flat
FEATURES Oval Oval Round Round Round Oval
BUILD Indian Indian Zulu Zulu Zulu Zulu
TEMPERMT Excitable Equable Excitable Excitable Equable Equable
Chinese
Xosa
SKIN: Black Yellow Light brown
HAIR: Crimpy Straight Crimpy
EYES: Round Almond Round
ORBITS: Straight Oblique Oblique
EYEBROWS: Thick Thin Thin
MENTALITY: Poor Fair Defective.
Norwegian
Coloured (White & Hottentot)
Chinese
Coloured
thin, oliv
hair, golden crimpy
Eyes, oval, long, hood
Orbits, straight
Eyebrows, medium
SKIN: Light brown Olive Light yellow
HAIR: Fair, straight Dark, straight Dark, crimpy
EYES: Narrow, oval Large, oval Narrow
ORBITS: Straight Oblique Straight
EYEBROWS: Thin Medium Thin

FIG. 4

to me but can not be dealt with in detail. Among them is a family derived from a Madrassi man and a Zulu woman. They have four children. The African type of hair, lips, nose and temperament is shown by three of them, the fourth showing mostly Indian characteristics.

A Transvaal family, founded by a Rajput man and a Shangaan woman, consists of two sons and two daughters. The elder daughter, mostly of Indian type, has married a Natal Indian and has two children of Indian facies but with rather crimpy hair. The younger daughter, native in type, has married a Shangaan and has two native-looking children. The elder son has married an Indian wife and their baby daughter, four months old when seen, apparently is Indian in appearance. The younger son has married a Colored (Dutch-Thonga) woman and their two young children are native in appearance.

Another family, founded by an Indian of Bengali descent and a Dutch-Hottentot woman, consists of three sons and two daughters, all unmarried. The eldest son is Indian in appearance and temperament. The second son is largely Indian but with slightly crimpy hair. The third son is largely native in appearance. Both girls and one boy have high cheekbones and one girl shows steatopygia.

European, Asiatic and African blood are combined in members of the two last-mentioned families.

Chinese admixtures are now being produced in small numbers by intermarriage between Chinese and natives and Colored people. A few examples may be given.

A Chinaman, born in Amoy but now living in South Africa, has married a Xosa woman, who has become dull and stupid. They have three children. The characteristics of the family are shown in Fig. 4 (middle). The eldest son looks like a pure native, the second son is typically Chinese and the third son combines crimpy hair with Chinese features and is mentally defective. Such a marriage between Chinese and full-blooded native is not common, but is indicative of what is taking place in the community.

The family whose characteristics are shown in Fig. 4 (bottom) was founded by a Chinese from Singapore. His wife is a Colored woman, the child of a Norwegian father and a mother of mixed white and Hottentot parentage. This woman looks European, with almost golden though crimpy hair. They have three children. The two sons have the general appearance of Chinese, though one has fair, straight hair and the other dark, crimpy hair. The daughter has almost a Syrian look, but with oblique orbits. The family seemed healthy, clean and prosperous.

A Chinese man, born in South Africa of Cantonese parents, first married a Chinese woman and later married a Colored woman of Dutch-Fingo origin as his second wife. Of the three Chinese-Dutch-Fingo children, one son and the daughter are of Chinese type, with straight hair and almond-shaped eyes, and one son is distinctly native in appearance and temperament. The hybrid family is of good physique and the Chinese characteristics are dominant.

A Chinese man married a Colored woman of mixed Dutch and native blood as his third wife, her two predecessors being Chinese. The five children of the last family show marked hybrid variation. One son is Chinese in facies but has a very dark native skin. One daughter has a yellow skin, scanty eyebrows, straight orbits, round eyes and crimpy hair. Another girl has brownish skin, straight hair, thick eyebrows, oblique orbits and narrow eyes. The second son is Chinese in appearance and the third son resembles his mother but has a yellowish-white skin.

A Chinese man, born in Kowloon, went to South Africa and married a Cape Colored woman of uncertain

origin. They have four sons and one daughter. The eldest son, of Chinese appearance and manner, has married a Cape Colored woman and has two sons, much like him. The second F_1 son is like his father in color and seriousness but is otherwise native. The third F_1 son looks and behaves like a native, is married to a Zulu woman, has two sons and a daughter of native appearance and one daughter of Chinese appearance. The fourth F_1 son looks like a Cape Colored man and is married to a woman born in the East Indies and said to be "part Chinese." The fifth F_1 member, a daughter, is dark-skinned, with negroid eyes and lips, is married to a Chinese and has two little boys of Chinese appearance

Many variations in physical features occur in this family, but, on the whole, the Oriental is dominant, and two of the first filial generation have shown their strong affinity and sympathy with the Oriental by their marriages.

The four families last mentioned are of much interest as they each clearly combine European, African and Asiatic blood.

Another Chinese admixture, but of a different type, has been observed in which the parties were an Indian man of Tamil stock, taken to South Africa as an infant, and a Chinese woman, who was born in South Africa. They had six children. The first-born, a son, died immediately after birth. The second, a son, is typically Indian in appearance and has a violent temper. The third child, a daughter, is Indian in appearance but is placid. The fourth child, a son, is now dead, but is described as being like his Indian father. The fifth child, a girl, is small, with a yellowish skin, oblique orbits and a violent temper; she looks Chinese. The sixth child, a boy, also looks Chinese and is placid in temperament.

In comparison with the Chinese crosses with African and Eurafrican, already cited, the Chinese characteristics, derived here from the maternal side, do not seem quite so evident in the offspring—but both parents are Asiatic.

Two cases of Eurasian admixture may be of interest, occurring, as they do, in a South African setting.

A German merchant married a very pretty Indian Tamil woman. After a stay in East Africa, they went to Natal. Their family consists of five children. Two of the sons married Natal Tamil women, one daughter married a German man. The elder son and his Tamil wife have two typical Tamil children and the younger son and his Tamil wife also have two children, both Tamil in appearance. The German-Tamil woman married to the German has three children, one son being distinctly German in appearance, the other son and daughter being nearer the Tamil side of the family in appearance and temperament. Social factors here have come into consideration. The families of like racial constitution are happier than the one in which there is a larger proportion of European blood, and there is mutual dislike between the cousins. The German husband of the German-Tamil wife is a Lutheran, while she is a Buddhist, and the children, so far, have been educated as Lutherans. The German-Tamils married to Tamils tend to be happier, for with them there is less upset of social ideas and of social inheritance.

A Scot married a high-caste Rajput woman in her home land. Twin boys were born to them, and after the parents settled in South Africa a baby girl was born. The boys are like their mother in features and hair and are strong and healthy. The baby girl had a quite fair skin when seen.

Remarks on Racial Admixture and its Effects in South Africa

The white population in South Africa, as already mentioned, is greatly outnumbered by the non-white, and many prob-

lems naturally arise therefrom, as well as from the impingement of the one race on the other. The whites constitute what has been termed an "aristocracy of labor." They are the originators and planners of schemes, supervisors and directors, manufacturers, farm proprietors, clerical, legal, religious and educational workers. The natives are the manual workers. The Cape Colored people are in an intermediate position. The Colored men are good market gardeners, and some attain considerable skill as house painters, carpenters, chauffeurs, mechanics' assistants, waiters and the like.

With increasing education of the Colored population and of the natives, the less well equipped of the whites, particularly the "poor whites," find themselves in difficulties. Because of their white skins, the "poor whites" consider themselves part of the "aristocracy of labor" and despise and often refuse to do unskilled manual work for which they are physically fitted—to them it is "Kafir's work." If willing to do such work, they find themselves in competition with natives, who are often more competent and easier to manage than themselves. For skilled work there are too many non-submerged whites, and the lower strata of white society, above the "poor whites," are finding themselves in competition, not only with the Cape Colored people, but with the better educated and more intelligent natives. It must be stated that the government has tried to rehabilitate the "poor whites" by land settlement in good irrigated areas and by labor colonies, but their numbers still increase.

The problem of feeblemindedness among the "poor whites" is of great importance. Racial deterioration due to undue proportional increase of the unfit is insidious and must be stopped. Segregation of persons with marked hereditary defects is necessary, and some means of preventing the propagation of the mentally and socially inadequate is absolutely essential for the continuation of white civilization. Recently, an increase in feeblemindedness among natives and Coloreds has been noted, and this needs careful attention.

In connection with feeblemindedness, there is the danger, as elsewhere, that high-grade morons may enter the Union of South Africa as immigrants, with the inevitable consequences. In regard to any scheme of immigration, the working skill of the immigrants, their standards of living, moral ideas, assimilability in the new land and the effect of their social characteristics on the established population need the closest consideration.

Social inheritance and racial admixture are closely connected and in subcontinents like South America and South Africa, where white and non-white live side by side, are of great importance. In South Africa, the natives are at a lower level of civilization than the whites; also, the Asiatics have different standards of living and morality. Social inheritance involves the ideals, sentiments, moral standards and general relations of life. A person instinctively adopts the relations of family, civic or tribal responsibilities that his parents did and, in the community, actions against the standard of life of that community are barred. The general average of communal or family behavior and attitudes towards life are thus maintained, the majority, from force of circumstances, remaining within the limitations imposed by inherited public opinion. Continuity is thus assured of the *best* opinions of preceding generations.

Racial admixture, even between whites, tends to break the continuity of thought and customs, especially when the crossings are between peoples not closely related by common origin, language, habits or religion. The contrast, naturally, is more marked between whites and

natives, who have very different outlooks on life. Scientifically, there are two great groups of fundamental differences between white and black; firstly, physical and mental differences due to inheritance, which are biological differences, and secondly, differences in religions, customs, traditions, ideas and their consequences, which are social differences.

From my studies of large numbers of Eurafrican crosses in South Africa, of which a few examples have been given, such crosses are not to be commended. There is invariably an alteration of social customs and loss of social inheritance by the offspring. The Colored race has not the energy nor the persistence of the white, is less stable temperamentally and is not controlled by the tribal conventions of the native. Dislike by them of the native connection seems general. Numerous social grades exist among the Colored people and those with more white blood despise those with less. In the lives of "mixed" families, there appear to be great inequalities: while the white parent tends to sink, to become more animal-like, less energetic and more careless, the black parent loses respect, no longer regards tribal authority and, on the whole, is not raised. Dislike for such unions on the part of the community is really based on incompatibilities of racial temperament and social inheritance. While unions between whites and natives are now forbidden, there is no bar to marriage between white and Colored people.

In most Colored families there is evidently great desire to be considered white and for the women to marry white men—sometimes with disastrous consequences when very dark babies are born. Evidence of this trend is afforded by advertisements in Cape Town newspapers of preparations for taking crimp out of hair and of special cosmetics for olive skins. A hopeful feature is that some Colored folk now have stronger views on racial relations and are intermarrying with one another, both appreciating the handicap of their origin. A more stable element in the population is being produced thereby.

Another fact that has often been noted is the bad health and poor physique, especially in the first cross, of the offspring of many racial admixtures in South Africa. Susceptibility to pulmonary complaints, in particular, seems intensified. Bad teeth are extremely common, even in quite young people. Other physical disharmonies, such as large native teeth in small European mouths, small internal organs and deficient circulatory systems in tall Eurafrican men (seen post-mortem), differences in glandular constitution and the like have been noted in many cases. Such conditions produce physical disability, the organisms can not compensate and such individuals are relatively short-lived. Mental disharmony often accompanies the physical and is shown by violent outbursts of temper (often for no apparent reason), personal vanity and sexual instability. Such features are shown by Colored people living in good environments and often on a higher plane than those of the "poor whites," so that environmental factors are not the cause of the manifestations. It seems clear that for both social and physical reasons, white and black are best apart.

The Malays, well known at the Cape, particularly in the Western Province, are reputed generally to keep to themselves, which is all to the good. They make good craftsmen in the building trades and their competence as fishermen has already been mentioned.

Other features, perhaps small now, but bound to be of increasing importance, are the creation of a South African born Eurasian element and of an Afro-Asian admixture. The social status of the Eurasian is usually not a particularly happy one and their position in the community remains to be determined.

Crosses between Indian men and native women occur and in some districts the native women have favored the Indian men more than their own race, a feature resented by the Indian women, in the families of which the natives became members and by the native men, who disliked their women's departure from tribal tradition and control.

The infusion of Chinese blood in certain places among native and Colored peoples, though relatively small, is greater than was at first suspected. In many cases, the Chinese facies seems to have impressed itself upon many of the offspring. The mental characteristics of these hybrids vary, but the Chinese temperament seems to predominate. The native and Colored partners give the Chinese good names as providers, industrious workers and companions. The children certainly show more initiative than native children.

In general, as I have often stated, while intermarriage of black and white is not desirable biologically or socially, yet that does not condemn racial admixture as a whole, for admixture of peoples at similar levels of civilization may result in the perpetuation of highly desirable qualities. In South Africa and other countries where the color problem exists, more attention to the maintenance of racial integrity seems desirable. In South Africa, Colored hybrids tend or did tend to dislike and distrust the parental races on both sides. The best social results seem to accrue, as in the Cape Colored people, when Colored hybrids intermarry among themselves. Mutual respect between races does not necessarily imply social equality. This consideration should be sufficient to prevent such intermarriages as would result in the upset of good traditions and physical, mental and social harmony.

The standard of health of a population is always a matter of paramount importance. Importation of labor from India in the past brought hookworm disease to Natal and Kimberley, and native laborers from Portuguese East Africa have more recently spread hookworm on the gold mines of the Witwatersrand. Industrialization of natives and Colored peoples has led to increased exposure of them to maladies such as tuberculosis, silicosis and pneumonia. They, in turn, have acted as reservoirs of diseases, such as malaria and bilharziasis. How the newer racial strains in the South African population will react in health matters remains to be seen. One thing is certain, both native and Colored need far more instruction in sanitation and in better agricultural methods. These, as well as racial impacts and racial admixture, are subjects for eugenic research.

Fortunately, the need for such eugenic research has been realized. In South Africa since 1920 there has been an active Eugenics and Genetics Committee of the South African Association for the Advancement of Science, which is a member of the International Federation of Eugenic Organizations, and work on racial admixture has been published by the Association. Also, since 1930, there has been a Race Welfare Society in Johannesburg that has maintained a family welfare center for married women, and a center with similar aims is working in Cape Town. These organizations also serve for propaganda on matters pertaining to the maintenance of health, the encouragement of propagation among the better types in the community and the restriction of the same among the less mentally and socially adequate members. The subjects of racial integrity and race admixture are intimately interwoven with the health and prosperity of any nation and must commend themselves to all eugenic organizations.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

FOSSIL FOODS

By Professor RALPH W. CHANEY

CHAIRMAN OF THE DEPARTMENT OF PALEONTOLOGY, UNIVERSITY OF CALIFORNIA, BERKELEY; RESEARCH ASSOCIATE, CARNEGIE INSTITUTION OF WASHINGTON

THE question of what to eat is one which has been asked by man and his fellow creatures as long as they have lived upon the earth. Our human ancestors, roaming the hills of northern Asia, primitive horses which ranged over western America, the dinosaur as he lumbered about in the swamps of Alberta —all asked this question. I shall tell you something of the answers of the earth to the insistent demands of its creatures for food. These answers have been recorded in the rocks of distant ages, along with the skeletons of the questioners; they are uncovered by the paleontologist as he journeys back into the past in his search for fossils.

Several weeks ago, in a small town in the mountains of southern Mexico, I passed the hotel kitchen just at the hour that dinner was being prepared. There I saw the cooks grinding corn and meat with an implement called a *metate*. It is a three-legged stone platform with a stone rolling pin—an implement which has been used by primitive people for long ages, in fact, back into the stone age. Seeing this ancient kitchen utensil in use, and later eating the well-cooked food prepared with it, I could almost imagine that I was living back in the days before steel or even wood were used by man, when stone, crudely or cleverly fashioned, furnished the tools for all human activities. I realized, too, that such simply constructed implements limited the possibilities of variety on the menu. Apple pie, or even ham and eggs, could hardly be expected of a stone-age cook.

There is always the possibility, however, that prehistoric cooks might have surprised me. Our Chinese cooks in Mongolia, with the simplest of fuel and with no real ovens, baked enormous chocolate cakes on the birthday anniversaries of members of the Central Asiatic Expedition. What they lacked in equipment, these cooks matched in cleverness. They baked a cake in four sections, using gasoline tins for ovens. Later they spliced the sections together with frosting. The stone-age cooks may have been equally ingenious. In any event, the record of their activities, buried in the cave deposits of northern China, shows how they supplied a vitamin element to the diet of their stone-age families.

Central Asia has come to be considered the home-land, the point of origin, of many of the animals now living upon the earth. When Davidson Black and his Chinese associates found the skulls of Peking Man in the caves of the Western Hills near Peking, China, critical evidence was added to support the theory that the human race also arose in or near that region. In addition to remains of man, they found many bones of horse, deer, rhinoceros and bison. Some of these had been split, others were partly burned. Clearly they represented the remains of animals which had been killed and eaten in the cave homes of Peking Man. We use the word "garbage" for the refuse from our tables, but such a

word may seem inappropriate to the anthropologist and paleontologist, as applied to his choice specimens. A hundred thousand years hence, our garbage may be interesting to future students of man; let us hope they will have a more respectful name for it. In any case, leftovers from the table of Peking Man are the only direct means we have of reconstructing his food habits.

Down in the dark interior of the cave in which he lived are piles of ashes from the fires of this oldest man of Asia. Enough of his skeleton has been found, embedded in the cave deposits, to indicate that Peking Man was a creature able to think and to talk. The crude slivers of quartz left at his fireside show that he had acquired the human habit of using implements to cut or crush his food, and perhaps to scrape the skins which he may have used for clothing. Sifting over the debris of his home, left on the floor of the cave perhaps a million years ago, I found the bones of animals no longer living in northern China, animals which he used for food in the days before game laws limited the size of the hunt. From our present-day knowledge of the importance of plant material in a balanced diet—from the prevalence of spinach weeks, prune festivals and apple-a-day slogans—we might have guessed that without some sort of plant food this early ancestor of ours could not have been sufficiently nourished to prolong the human race; but I did not expect to find the remains of such food since most fruits and vegetables do not have structures which resist decay, as do the bones of animals. Who ever heard of fossil carrots or oranges?

At the end of my stay at Choukoutien, the small town in the Western Hills near Peking where the cave is situated, the Chinese paleontologists in charge of the excavation told me I might select a specimen to take with me. I chose a piece from a large rock-pile lying at the mouth of the cave; fragments of bone and quartz flakes were exposed on its surface. It was a little too large for me to carry, so with my hammer I trimmed off a projecting end. To my surprise, on the broken surface there appeared a round seed the size of a small pea, a seed which I immediately recognized as that of the hackberry. Modern hackberry fruits are something like cherries, but with only a little juice. Hackberry trees grow in many semi-arid parts of America, where birds feed upon their fruits. In the southwest, Indians commonly use them for food. The occurrence of this seed in a mass of rock containing the quartz implements of Peking Man and bone fragments from his meals of long ago seemed of great importance. Here might be a fragment of the oldest plant food known in the human record. But if hackberries had been generally eaten by this early inhabitant of China, there should be more than one of them preserved in his cave. One seed does not make a supper.

A careful search of its walls revealed a layer made up of almost nothing but the broken shells of these fruits. As though they had been crushed in a grinder and thrown aside, there they lay. Were they the food of early man or of some other animal which had lived in the cave? Months later, in my laboratory at the University of California, I answered this question. With the idea that prehistoric squirrels or rats might have carried these seeds into the cave for food and left the shell fragments there, I fed modern hackberry seeds to living rodents. But the squirrels and rats were not interested in such food. Even if they had chewed them, they might have been expected to gnaw off one end of the shell, as a squirrel opens a nut, rather than to break them into fragments like those in the cave. Evidently the fossil hackberries were not brought into the cave and opened by rodents. Then, with one of the quartz implements of Peking Man, I crushed some of the modern seeds. Their shells broke into pieces which were

exactly like the fossil fragments from the cave in China. Modern American Indians grind hackberry seeds on their *metates*, using the juice for flavoring and throwing aside the broken shells. We may suppose that Peking Man, at the very dawn of human history, crushed hackberry seeds with his crude stone tools and secured his vegetable vitamins from the fruits whose broken shells are buried with the bones and implements in the cave deposits at Choukoutien.

Man and his relatives eat a wide variety of foods; but certain animals are almost exclusively vegetarian. Elephants roamed the plains of central Asia a million years or more before Peking Man came to live in the caves of China. They differed from modern elephants in having a long scoop-shovel, formed by the lower jaw and teeth. With such a mouth they could not feed upon leaves in the forest, after the manner of their modern relatives. Rather their jaws seem suited for digging or dredging. Only recently, when Sven Hedin and his expedition crossed Turkestan, there were discovered deposits containing fossil plants which lived at the time these peculiar shovel-tuskers ranged over Asia and into western America. Along with the fossil leaves of poplar and elm, there were found pond-lily leaves and roots, and the stalks of cat-tails and coarse grasses. Here was a source of food for the shovel-tuskers, a type of food still used by the largest American mammal, the moose. Occupying a region too dry for extensive forests, which supply food to most elephants, past and present, they came to depend upon vegetation in lakes and swamps—aquatic vegetation which they shoveled up from the muddy bottoms. With the final drying of these lakes and the disappearance of the water plants, shovel-tusked elephants became extinct.

Changes in food not only have caused races of animals to disappear from the earth in the past, but they have brought about important changes in the animals which survived. The first horses, living in North America more than fifty million years ago, were forest types, browsing the leaves of bushes like sheep or deer. Gradually forests became more restricted, until they occupied only the borders of streams, with grasses covering the plains above. Under these new living conditions, the ancestral horse needed longer legs. Without the protection of the forest, speed was essential for escaping from his enemies and for covering long distances to water. With longer legs and the need for reaching to the ground for grass, a longer neck was required. My friend, Maxim K. Elias, of the Geological Survey of Kansas, has recently found fossil remains of grasses, buried in rocks which also contain the bones of the horses which fed upon them. Grass has in it a hard substance known as silica, which wears the grinding surface of the teeth of animals that eat it. Development of high-crowned teeth was a necessity in view of a changing diet from juicy leaves to hard grass. During long ages horses have increased in size, with longer legs built for speed, and with teeth suited to last a horse's life-time. Because of these changes—because he was able to eat grass, the horse has been able to survive upon the earth, while many other creatures have disappeared.

From the evidence of paleontology, which is a study of the history of life upon the earth, it is apparent that food plays an important part in controlling animal populations. When early man discovered that he could plant grain and secure a large supply of food, he no longer needed to eat hackberry seeds in the dim light of a cave. A cooling and drying climate caused the disappearance of the shovel-tuskers. The spread of grasslands as a result of these same climatic changes has made the modern

horse an efficient running and chewing machine. The earth itself is responsible for the changes in us and in our food.

There is no reason to suppose that earth changes may not take place in the future. Such changes are commonly too slow to be detected in a human lifetime, but over long ages of geologic time they may greatly affect our race. The only method by which we may determine what our food, what we ourselves, may be like in the future, is to survey the changes of the past. By an interpretation of the fossils which were the living creatures of yesterday, by uncovering their foods representing the vegetation of the past, we may come to understand why we eat as we do to-day—what we and our foods may be like in the to-morrow of earth history.

WASTE BY WIND AND WATER

By H. H. BENNETT

CHIEF OF THE SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

It was not so long ago that enormous dust clouds were rolling out of the Middle West to drop a stifling shroud over the country from the Mississippi Valley to the Atlantic Coast. In June, raging flood waters were bringing havoc to portions of three western states. The first week of July witnessed a tornado in Montana and a cloudburst and flood in New York. Since then Ohio and Wisconsin have experienced record-breaking rains followed by flood waters, and just a short time ago a disastrous hurricane in Florida was accompanied by torrential rains as far north as Maryland. Damage was estimated at millions of dollars.

But the estimates failed to include the most permanent damage of all—the destruction of the soil. Houses and other properties destroyed by the raging waters can be replaced; crops swept out by prairie winds can be replanted. But the fertile soil blown high into the sky or washed by the ton into streams and rivers is lost forever. Spectacular and destructive as these storms are, and as violent and harmful as the floods have been, they do not constitute the really great menace to our soil resources.

The truly tremendous waste is constant. Ruination of the soil is not confined to brief periods when nature exerts the full force of her elements. It proceeds steadily wherever man's cultivation of the land has bared the soil to the wash of descending rain and the sweep of the wind. There is no way of preventing cloudbursts. We have to accept them as they come and hope they will be few and far between. All we can do is attempt to control the floods that often follow.

Dust storms are different. Where cloudbursts are the product of some strange array of nature's elements, dust storms are brought on by man's own misguided failure to protect the soil as he tills it. By simple reasoning, therefore, if he can be guided into the use of practical measures of soil conservation, the cause of the dust storms will be removed. The very nature of these storms has given rise to the popular belief that they are the beginning and the end, the fact and symbol of all soil erosion. This is not true. The gradual washing away of rich topsoil by the runoff of rain-water is far more serious because it is not only constant but wide-spread.

In the work of erosion control, we have come to divide soil erosion into three classes; namely, wind erosion, sheet erosion and gullying. I need only to recall the dust storms to define wind erosion. Sheet erosion is the washing away of a thin layer of topsoil from sloping fields. Gully erosion follows in its wake to cut

deep chasms and ravines which ultimately ruin our fertile fields for cultivation. So we find our country's soil damaged by both wind and water.

Few people realize how tremendously important this land wastage problem really is and how certain it is to affect the permanent welfare of the nation. It is not generally known, for example, that approximately 50 million acres of our erstwhile fertile farm land has been essentially ruined for further practical cultivation; and that another 50 million acres is bordering on this tragic condition.

A nation-wide erosion survey, conducted last year by the Soil Conservation Service, revealed that the extent of damage and ruin to basic farm land far exceeds all prior estimates, and that the 100 million acres so severely impoverished or ruined do not tell the whole sad story. Something like 125 million additional acres, still largely in cultivation, have lost all, or the greater part of their most productive topsoil, with a direct decrease in crop yields that is appalling.

And here, for a moment, I should like to discuss the philosophy which underlies our objective of soil conservation. Right now, as every one knows, agriculture in this country is facing an economic crisis brought on by an accumulation of circumstances in which over-production had a leading rôle. Few people realize, however, that agriculture also faces a physical crisis of tremendous importance to the continuing welfare of this nation.

The remedy for the economic problems which confront the farmer must necessarily be of an economic character. It is, of course, necessary to adjust the total production to the total effective demand. Certainly there is no virtue in producing so much that the price drops to a point which is less than the cost of production. It is never advisable, it can never be wise, to sacrifice productivity. There is nothing incompatible or inconsistent between adjustment of production and conservation of natural resources. For the entire agricultural structure, after all, depends fundamentally upon the physical integrity of the soil. If that physical integrity is depleted at a rate which will see our entire cultivated acreage virtually nonproductive in half a century, there is no alternative for conservation. In other words, while we find it essential to control production, we must at the same time exert every effort to lower production costs, widen markets, improve quality of products and—this is what I wish to stress—maintain our basic resource, the soil. There is a danger, when the country is confronted simultaneously with agricultural crises of an economic and a physical nature, that this distinction may be obscured.

We likewise should remember that thousands of farmers have suffered continuous losses in revenue and are now fighting a losing battle against the poverty which is at least partially the result of extravagant, careless land use, as well as of price declines and maladjustments of the economic balance. If the farm land already ravished and ruined by soil erosion should be divided into 80-acre farms, and restored to its former productiveness, it would be physically capable of supporting no less than 1,250,000 families!

Soil erosion is a serious problem in every one of the 48 states. Naturally, in some states it is more acute than in others. Nebraska, for example, has been affected considerably more than Delaware. Erosion is more prevalent in Texas than it is in Vermont.

Yet we have learned from sad experience that a state comparatively free from erosion this year may be seriously menaced within a decade unless proper care is taken to conserve the soil. Who would have predicted, back in 1925, that the entire Midwest would be so severely hit by dust storms in 1935? Who would

care to predict what will happen in 1945 unless measures to protect the soil are taken at once? As can readily be understood, this is a national problem, which must be met on a national scale. The problem has gone beyond the local stage. It is no longer the concern of the individual farmer whether his land is washed or blown away. The very basis of America's future farming prosperity is at stake and that stake is too high for any but the most profound of considerations. Active leadership by state and federal governments is essential.

So the Soil Conservation Service, one of the youngest of established Federal Service agencies, has been assigned the job of saving our remaining area of good farm land from destructive erosion. It is a sizable commission, but we are moving ahead. The Service proposes to promote farm practices that will protect and conserve the farming lands of the country for permanent agricultural use. Certainly there can be no broad advance or strengthening in the individual farm position; or in upbuilding farm communities, until the land involved is stabilized in relation to soil erosion. In different words, the betterment of economic and social aspects of farm life is closely linked to the solution of the erosion problem.

If the Soil Conservation Service can initiate erosion-control measures on all seriously eroding lands within the next 10 years; if it can secure reasonable control of erosion within the next 20 years; and if it can establish preventive measures on practically all the better lands of the country within the next generation, it will have gone a long way toward solution of the problem. Although the Service has been in existence less than two years, it has already brought an area of approximately 40 million acres under its influence. Plans for expansion will more than double this area at an early date.

We appreciate the gigantic proportions of the task in front of us and are approaching it in all humility. We realize that the job can never be completed successfully without the concerted action, the consistent support and the creative cooperation of the whole people. For, after all, it is primarily and fundamentally a problem of the whole people. The task of conserving the soil is so vast and erosion has already made such headway that the Service could not possibly hope to treat all the land of the country, acre by acre, with necessary measures of erosion control. The job must be done through cooperation between federal and state agencies on the one hand and the farmers and landowners on the other.

The procedure adopted at the outset is one of demonstration. In this way the Service is able to carry its program to the greatest number of farmers with the least expenditure of time and money. As any thinking man will realize, the work of soil conservation must be carried on as economically and quickly as possible.

So, by demonstration, the Service is attempting to show that the impoverishment and destruction of our remaining areas of good agricultural land can be curbed to a very large degree. At the same time it is laying the foundation for a permanent national erosion control program of scope sufficiently broad to meet the acute land crisis created by wasteful methods of land utilization.

As a step toward its goal, the Service has established, or is in the process of establishing, 141 demonstration projects in 41 states, with the average working area for each project limited to approximately 25,000 acres.

Usually a demonstration project comprises all the land within a watershed; that is, all the land lying within the drainage basin of a given stream. Each project area is selected with the most careful consideration of its adaptability to an effective demonstration and its availability for inspection by a large number of farmers. In other words, a

project area must be readily accessible to a great number of farmers and it must present erosion problems that are representative of the entire surrounding countryside. If water erosion is prevalent in the region, the project area must present opportunities to demonstrate how water erosion can be halted. If gullies are numerous around the countryside, work on the project must show how gullies can be controlled.

The farmers of a project area enter into contracts with the government, whereby they agree to operate their farms under guidance of the Soil Conservation Service, to furnish as much labor and material as possible to put the program under way, and to maintain for a five-year period the cropping plans and erosion control structures installed by the Service. In return, the Service agrees to lay out a complete erosion control program for each farm, supervise the work and furnish whatever supplementary labor and material is needed to do a complete job.

Once the Service has placed its control measures in operation, the farmers in the surrounding territory are invited to visit the project and inspect the methods being used. It is hoped in this way to show them just how they themselves can control erosion on their own farms. A demonstration project is in fact a show window.

To-day more than 10,000 farmers have signed formal cooperative contracts, agreeing to carry out for a period of five years the control measures recommended by the erosion specialists as most adaptable to the needs of their lands. Yet the problem of soil erosion extends even further. In addition to the enormous loss incurred by abandoned acres, reduced crops yields and decreased fertility, the country is paying a heavy price for damage to its power and water supply reservoirs, its irrigation systems and its harbors and waterways.

Soil that is valuable on a farm is a menace when it begins to fill up our reservoirs and waterways. The soil washed from farms eventually empties into streams and rivers. Channels that had been deep become shallow. Unable to hold the volume of water within its banks, the river grows wider and wider, overrunning its former boundaries. The possibilities of floods are greatly increased.

Frequently the silt washed from farm lands comes to rest in the bottom of a reservoir. Little by little the reservoir fills up. The capacity is decreased. Millions of invested dollars in the reservoirs are endangered. Social and economic values dependent upon the reservoirs are jeopardized.

The control of erosion is essentially a matter of better land use. It means that we must be more careful—much more careful—of the type of crops we plant, where we plant them and how often we plant them. It means that the day of unintelligent farming is past, just as surely as the day of farming by superstition is past. We have progressed beyond the stage where farmers plant their crops only during certain phases of the moon and harvest accordingly. Farming to-day must be as efficient as a city industry.

The program of the Soil Conservation Service aims primarily at the establishment of agriculture on precisely such a basis of efficiency. Adoption of the program does not mean that production will be impaired. On the contrary, we have already proven that protection of the soil is compatible with production. Our objective is merely to readjust agricultural practice to the needs of the soil.

The realization of that objective is far off. Years of tradition have dictated the farm practices now employed in many of our major agricultural regions. We should be tilting at windmills were we

to attempt an overnight rearrangement of these practices, though, to be sure, we have accomplished almost that in several localities. We must proceed carefully, slowly and thoroughly to convince the farmer that our way is better than the way his father taught him. We must strive to inculcate in his mind a faith in our methods as strong as the faith that links him to the soil. We must instill into the farmers of America that almost reverent attachment for the land which has preserved the agriculture of certain smaller agricultural countries through the centuries.

Ours, certainly, is a goal fully worth the striving. For its attainment will mean that our children, and their children, and their children after them, in truth, "will inherit the earth."

AMERICA BEFORE COLUMBUS

By Dr. H. J. SPINDEN

CURATOR OF PREHISTORIC AND PRIMITIVE ART, BROOKLYN INSTITUTE OF ARTS AND SCIENCES

If the American Indians had not been living on cultivated crops in most parts of the New World, and if they had not already reached an urban civilization in tropical parts of America before Columbus landed on these western shores, the difference to the European nations who proceeded to conquer the New World would have been very great indeed. They would have found a land rich in natural resources but with none of its plants and animals domesticated. They would have been forced to live on game and wild fruits until such time as they could bring in the domestic plants and animals of the Old World. Their situation would have been like that of England in Australia, for in this southern land the lowly natives had developed none of the indigenous sources of food beyond the hunting and fishing stage. The English colonists had to import all domestic crops, both plant and animal, to assure themselves of food before they even could get started.

But in America the Indians had long since won from the wild a most important series of food plants, including maize, beans, potatoes, sweet potatoes, tomatoes and a long list of other valuable foods as well as other plants having industrial uses. These almost immediately became common property around the world and to-day in the United States the American series of domesticated economic plants makes up well over half of our agricultural wealth.

Now the people who had developed this permanent contribution to world wealth attained in Mexico, Central America and the Andean regions of South America to a high political status, with extensive kingdoms of theocratic type, that is, their rulers were gods or the spokesmen of gods. They had stone-built cities, high expressions of art in architecture, sculpture, metal working and textiles. The Mayas of Yucatan carried astronomy and mathematics to an advanced stage and also invented a kind of hieroglyphic writing which scientists are now attempting to decipher with some slight success. It is perhaps unfortunate that these nations accomplished so little in military science, for the most cultured peoples of America were soon overwhelmed by gunpowder and cold steel. It is not my purpose to draw a moral from the easy conquest of the Aztecs and the Incas by the mailed soldiers of Cortes and Pizarro. Of course, there was no ethical justification for this conquest. But within four hundred years the flag of Spain was again expelled from America and to-day we see the peculiar genius of the red man

imparting flavor and distinction to national life in modern Mexico and modern Peru.

The American Indian is racially related to the tribes of Siberia, and his ancestral culture seems to have been planted in the regions of Lake Baikal and the headwaters of the Yenessei and the Lena Rivers on the southern edge of Siberia somewhere between 2500 and 2000 B.C. This ancestral culture was that of men who hunted and fished in a land of forests and streams. They used polished stone axes of jade and other tough stones, harpoons with detachable bone points, bows and arrows, canoes and paddles, clothing made of sewn skins, baskets, nets, and occasionally made pottery. This culture, which we call Neolithic or New Stone after the polished axe, may have had its beginnings in the Baltic and Scandinavian countries. As the glaciers of the last ice age retreated, forests reoccupied most of the empty land and man entering these forests was able to take up his residence in more and more northerly regions. But, of course, he needed some form of axe in such a forest environment, and it seems he first used parts of reindeer horns for handle and blade as well. On the basis of archeological remains of pre-Neolithic and then of the Neolithic types it has been possible to establish successive northern frontiers of human occupation, first in Germany, then in Denmark and finally in Sweden and Finland.

Now the only available road to the New World lay across the narrow Bering Strait from East Cape in Asia to Cape Prince of Wales in Alaska. This road was located almost precisely at the Arctic Circle and of course it was not revealed till man had pushed his residence well beyond the peninsula of Kamchatka. According to the modern deflated chronology of north European and north Asiatic archeology, the date of the first coming of the red man to America was about 2000 B.C. There is, however, a vociferous American school who would like to have man in America at a much earlier time, say 10,000 B.C., or even 20,000 B.C. if it were possible. The reply which must be made to these is that glacial ice still blocked the northern road at such a remote epoch and that furthermore man in the Old World had not yet attained to the minimum stage of culture disclosed in all parts of America by the most primitive archeological remains.

No example of men of lower type than the present universal species which we call *Homo sapiens* has been discovered in America. Indeed this higher type of human being did not appear in the Old World till the last ice sheet was at its most southern stage, and it took him thousands of years, while the ice was retreating northward, to develop the tools and weapons which became the common heritage of the first American immigrants. Yet it is quite possible that man arrived in what is now territory of our United States, while some large animals now extinct were still living. Fine flint blades, of a peculiar type designed apparently for buffalo lances, have been found in the western plains in association with an extinct and partly fossilized variety of the American bison. Bones of the great ground sloth, and also of camels have been reported in association with fireplaces and other evidences of man's presence. Some have even thought that there were still mammoth in this land when the red man first arrived.

At any rate what a marvelous discovery it was: men, women and children streaming over into Alaska from the easternmost cape of Asia—ascending the Yukon, crossing through the valleys of the Rocky Mountains, following the ranges south with illimitable plains of grass on the eastern horizon. Game was awaiting them, herds of buffalo and antelope, gardens of edible roots and edible fruits. All they had to do was

stream in and occupy, bringing with them their kit of simple tools, their simple arts and ceremonies, their simple forms of government, which nevertheless contained the germs of social cooperations.

Mountain ranges are always the easiest natural roads for animal migrations, and man in America followed the Rockies and the Andes down to Tierra del Fuego. Seacoasts are next, and the Eskimo with a typical seacoast culture followed the shores from Alaska to Greenland. Streams lead through forests and are a third favorite road of primitive man.

Finally the two empty continents were peopled, the weakest tribes being forced into the less desirable regions. Then the more progressive societies attacked the food problem in a practical fashion. They found that by planting seed and spreading water on desert land one could raise crops. So maize was domesticated and soon afterwards beans and other plants. There were few animals to tame for meat diet, but the turkey was tamed and the muskovy duck and besides there were dogs and guinea pigs. Other plants were domesticated for economic uses, including cotton, which now supplies our mills. Tobacco was cultivated as the great medicine capable of inducing a philosophical state of mind. Rubber was manufactured into waterproof capes, into balls for spectacular games, into dolls and was even burned to make black, storm-cloud incense.

Out of the use of leisure saved from the pursuit of food the American Indian nations found they could support kings, priests and artists and build lofty temples on pyramids to satisfy their glory complex.

In the order of development of their civilization there was first the nomadic stage of the first immigrants. Such hunting and fishing tribes survive even to-day in the marginal areas of the far north and the far south. Next the stage of the archaic civilization was developed in arid lands by the first farmers. They delved and spun and made pottery. Thirdly, came the stage of the great wet land cultures, with the Mayas in the van. These began shortly before the time of Christ to show the way to most of the higher arts. But they had no metals, and carved with stone tools. The First Empire of the Mayas closed about 630 A.D. but the influences spread farther and farther afield. It seems there were cultural connections between Central America and Peru in the sixth century A.D. but the influences spread further in the twelfth century, when the Toltecs were in the ascendency. At this time gold and other metals were introduced from South America and metal working was rapidly improved. The rule of the Aztecs in Mexico and the Incas in Peru goes back to about the beginning of the fourteenth century. In the United States area there was a succession of arts, found on several archeological levels in the Southwestern states where the Cliff Dwellers lived and also in the valley of the Mississippi and Ohio Rivers, where the Mound Builders flourished shortly before the discovery of America by Columbus.

And then came the white man with no inhibitions against seizing land and wealth. In a short generation the grandeur that had been Mexico was no more. The daughters of the sun, who wove the finest textiles of the world in Peru, were paying tribute of their handiwork to be sold in the markets of Europe.

But even to-day and in our own United States the Indian comes back, irrepressible, with arts and illusions in his hands to enrich the new American civilizations.

ON THE PERSISTENCE OF USELESSNESS

By Dr. ROBERT A. BUDINGTON

PROFESSOR OF ZOOLOGY, OBERLIN COLLEGE, OBERLIN, OHIO

In the common New England starfish, *Asterias forbesii*, the extremely short and essentially non-functioning intestine supports an outgrowth termed the rectal cœcum. This is generally a minute, bifurcating structure, each branch subdividing into a number, occasionally as many as forty, of small branchlets and excrescences; the whole cœcum is hollow, its cavity continuous with that of the intestine. No necessary vital function for this organ is known, though it incidentally may augment the respiratory and excretory surfaces in a nearly negligible degree. It is essentially useless.

The conclusion just stated seems the more tenable because portions of mutilated starfish regenerate, and thrive normally afterward, although lacking this feature of anatomy. Furthermore, assuming the physiology of all five present-day groups of Echinoderms to be somewhat similar, in one as in another, the nonessential character of the starfish rectal cœcum is convincingly suggested by its absence in two families of the asteroid class. Only in one order of the Echinoderms, the Holothuria, is a comparable organ active functionally, and in it mainly as a "water-lung" or "respiratory-tree"; how actively seems to depend on the thickness and structural accessories of the body-wall.

Now, there is nothing unusual in the occurrence, anywhere among animals, of organ remnants, *i.e.*, vestiges, or debris from the evolutionary process, features of the old plans persisting after incomplete adoption of new anatomical patterns of external or internal architecture in consequence of changed external or internal conditions and advantages. Throughout the ageless time while the making of complicated organisms has been going on there have been many instances of style and trend in design; one may playfully employ the terms of ordinary parlance, *e.g.*, archaic, medieval, renascent, Victorian, modern, if he wishes, a difference in application to actual time-periods being understood; and these styles have been more or less copied and now and then mixed in intermediate generations, during the long process of animal and plant devisement and creation. The while these procedures, looking toward "a new day," have been in process, a kind of conservativeness or inertia seems to have compelled the younger progeny not only to accept the general parental formula as to anatomy and physiology, but he has had foisted upon him from the "what-not corner shelves" more or less equipment bequeathed to his family by relatives scattered along many million years of the ancestral trail. The proud human, who rates himself to be quite a novel and "modernized" arrival on the stage of animal society, may correctly reflect that anatomically, physiologically, intellectually, he is scarcely more than a walking museum of "hand-me-downs." His chance for "success" and "distinction" among the intelligentsia, or among prize-fighters, lies, not in any marked newness of his personal components, but mainly in the fact that his particular combination of parts and the results possible thereto has doubtless not occurred before. Ecclesiasticus, 1000 B. C., and thus with but a moiety of the mass of evidence before us, precociously and too pessimistically, but with considerable correctness, thought through to the conclusion: "The thing that hath been, it is that which shall be; and that which is done is that which shall be done; and

FIG. 1. A. RECTAL COECUM OF *Asteris forbesii*, THE COMMON NEW ENGLAND STARFISH. ENLARGED 4 ×. BLACK PAPER BENEATH THE COECUM. B. CLOACA AND "RESPIRATORY-TREE" OF *Thyone briareus*, A "SEA-CUCUMBER." THE SEVERED INTESTINE, AMPULLAE OF "TUBE-FEET," AND PORTIONS OF LONGITUDINAL MUSCLES ALSO SHOW. PHOTOGRAPHY BY A. L. PRINCEHORN.

there is no new thing under the sun." Old life materials and their functions have been remodeled or emphasized, often repressed; but most of them were used in some degree even in that early (and present-day) masterpiece, *Amoeba proteus*.

In thus assuming to remark upon an instance of biological uselessness, some one may ask: "Why not deal with some of the eighty and more advertised, dust-covered relics in the human body? Make the matter intimate!" True enough, but even the appendix and tonsils are defended by some as indispensable; and the "high forehead," in spite of the proven uselessness of the cerebral frontal lobes, receives obeisance. Each of these structures, and all others in human anatomy, is, of course, a survival and heritage from "lower" vertebrate ancestors; but for our present thesis they are of relatively small value for the reason, on the one hand, that all vertebrates are very much alike; and furthermore because the primates are such recent arrivals that we do not yet venture to surmise how long they, as wholes, or their parts, may maintain themselves as the future geological eras begin and their eons pass. We have chosen to look elsewhere for a more persuasive instance of persistent anatomical and physiological uselessness; incidentally our case is thereby given argumentative advantage since, in the popular mind at least, anything in an invertebrate animal may seem less vital and necessary than most things in vertebrate structure—and consequently their perpetuation that much less explicable.

The general plan of organization for starfishes and all their near relatives, *i.e.*, sea-cucumbers, sea-urchins, serpent-stars and crinoids, was determined in pre-Cambrian times, *i.e.*, before the time when fossiliferous, telltale rocks were laid down. Starfishes were already abundant and of numerous species before the paleontological family album was installed; since no one knows within a wide range of centuries how long ago that was, convenience lets us mention a conservative estimate of two hundred million years, half of the guess of some wise men; and the insignificant rectal coecum of the starfish was doubtless in existence and already a relic long before that. How many million years previous to the arrival of the earliest, lowliest vertebrate that was is a matter for further conjecture.

As indicated in the introductory paragraph, the original use of this humble intestinal outgrowth in the starfish physiological economy, or at least in that of its ancestors, seems to have been that of a respiratory organ, and thus doubtless filled and emptied as repeatedly as "breath" was needed. This assumption is made, in the main, because of its simi-

larity in relation to other organs, in its structure and in its behavior to that of a corresponding or homologous structure in the related group of Echinoderms, the Holothurians or sea-cucumbers; and there are reasons aplenty for this assumed relationship. The question, then, is: "In what degree has inheritance from a common ancestor determined that an organ, useless in the animal under discussion, shall resemble a similar organ still essential to and maintaining its original *raison d'être* in another branch of the phylum?"

Four sorts of similarity between the starfish coecum and the cucumber "respiratory-tree" will now be cited, as sufficient illustration of the truth of the contention that nature, in living things, using the instrument of inheritance, does not easily "forget" or "let go"; and it is assumed that the cloacal diverticulum in holothurians is a coecum "at its best." First, the star coecum, one two hundredth the volume and weight of a full-grown cucumber "lung," retains, in miniature, the general form of the latter (Fig. 1). Both are branching, dendritic objects, their terminal twigs being rounded bulbs; the diminutive coecum could easily be taken for one of the ends of the numerous branches of the "water-lung." That each is an outgrowth of the terminal section of the food-canal of its respective animal is a simple fundamental fact, itself practically establishing their homology. Thus, even this early, we may at once ask the question, "Why should the starfish have any such unnecessary family appendage fastened upon it?"

On examining the coecum and the "lung" internally, in sections, again their likeness is evident (Fig. 2). Each is hollow (fully expected in the "lung"), and the inner cavity of each is invaded by processes and folds of the lining tissues; vesicular spaces occur in some of these processes; the same tissue layers, though of not the same thickness in both, comprise the walls of each. Thus, although superfluous, the coecum has continued to be made from the same blueprints, little has been forgotten or omitted in all the unmeasured time-eras since the original idea of a rectal diverticulum was adopted.

The retention of plan of structure by an anatomical remnant may seem more easily expected than that any trace of function should at all persist; the former could be more or less perpetuated while function became numbed or nil. As a matter of fact, the star coecum does seem so near "the end of its rope" that its re-

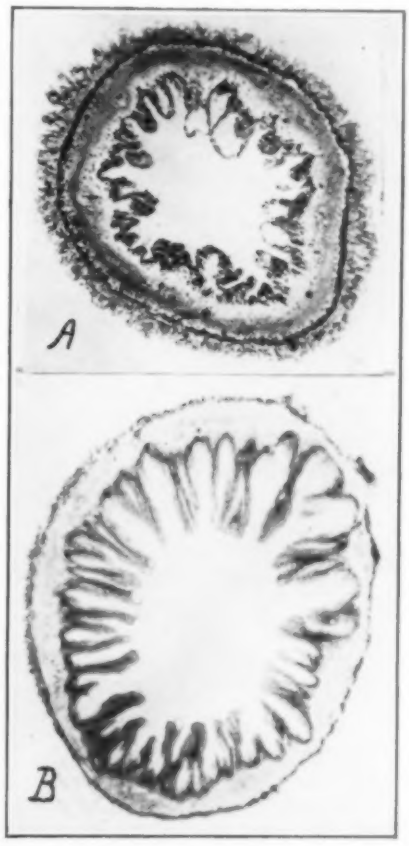


FIG. 2. A. CROSS-SECTION OF A LOBE OF A "RESPIRATORY-TREE." B. CROSS-SECTION OF A BRANCH OF A STARFISH RECTAL COECUM. THE MUCOSA IN EACH IS DISPOSED IN FOLDS AND PROCESSES; IN THESE VESICULAR SPACES OCCUR. PHOTOMICROGRAPHS; ENLARGEMENT ABOUT 70×.

spiratory rôle is doubtless negligible, if indeed it serves that office at all; and in that respect it fails to match the major usefulness of the "respiratory-tree." Nevertheless, the chemico-physiological studies of such men as Pourtales[1] in 1851, van der Heyde[2] in 1922 and others in the intervening years have demonstrated that the two organs being compared have each some slight excretory function in the ordinary sense of elimination of nitrogenous wastes. This "service," though doubtless quite perfunctory as regards the prospering of either the "star" or its cousin "cucumber," does furnish a third evidence of their parallelism; and its non-significance to, but retention by, the asteroid coecum adds further comment on the phenomenon which is being termed "the persistence of uselessness."

A further characteristic of the living rectal coecum of the star, hardly to be anticipated in so vestigial an accessory, is its habit of rhythmic contraction. If long ago scrapped as a respiratory instrument, its pulsatile behavior seems inexplicable, save that it continues as an inescapable (as are all inherited items) and unforgettable grandparental procedure which, in this case, may be rated as an imposition. This action-requirement, "wished on" the coecum through millions of centuries and countless generations, makes the traditional visitation of "the sins of the fathers upon the children" through mere integer generations appear little short of simple forgiveness.

The inhalation-exhalation pump-action of sea-cucumbers is, as all familiar with it know, nearly as regular and rhythmic as that of man, and probably for the same reasons. A stop-watch recording of the breathing rate of the cucumber, *Thyone briareus*, for one hour totaled one hundred sixteen "breaths" in that period; a similar watching of the coecum's behavior gave a count of thirty-five for the same period. Perhaps this difference in respiratory frequency could be interpreted as an apparent forgetting by the star if by that is meant that the coecum's use is waning and becoming, contractions and all, a part of its general vestigiality. If analyzed carefully, after their recording by delicately adjusted kymographic apparatus (Fig. 3), numerous details of

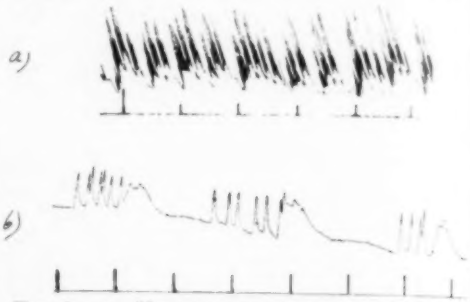


FIG. 3. a. KYMOGRAPH RECORD OF RHYTHMIC CONTRACTIONS OF THE CIRCULAR MUSCLES OF CLOACA OF *Thyone briareus*. b. SIMILAR KYMOGRAPHIC RECORD OF CONTRACTIONS OF THE STARFISH RECTAL COECUM; *Asterias forbesii*. BOTH CURVES SHOW MARKED PERIODICITY. TIME CURVE IN BOTH, 10-MINUTE INTERVALS.

movement manner prove to be very much the same in both respiratory-tree and coecum; one of these, and the most obvious, a form of hiatus or "sigh," has been hereditarily repeated in both his modern progeny as a legacy from a mutual ancestor's respiratory usage. Just as with the human who normally changes but about 15 per cent. of the air in his lungs at each breath, but who occasionally interrupts his breathing pace to take "a deep one" and more thoroughly ventilate his lungs, so too the holothurian breaths occur in groups; and these periods are probably associated with the filling of the extreme end-bulbs of the water-lung, after which the shallower exchange is again resumed until some respiratory shortcoming once more provokes the "sigh." This periodicity in

[1] Pourtales, "On the Holothuriae of the Atlantic Coast of the United States," *Proc. Amer. Assn. Adv. Sci.*, 5th meeting, Washington, 1851.

[2] H. C. van der Heyde, "On the Physiology of Digestion, Respiration, and Excretion in Echinoderms," *C. de Boer, Jr.*, Den Helder, 1922.

the cucumber's breathing doubtless has some significance for it, if not that just suggested; but why should a "habit" of this sort be retained by the starfish coecum? The most plausible assumption which can be made is that this neuromuscular behavior, in the star coecum certainly a genuine idiosynerasy, is a contracture requirement carried by some innocent chromosome unable and presumably undisposed to shake it off. Each succeeding generation of an incalculable total has unconsciously and unavoidably preserved this strange internal activity, and willed it to the next, even as to details, nearly *ad infinitum*.

Thus has uselessness, resident in specialized protoplasm, persisted; in this instance its abode, the starfish rectal coecum, has run parallel to the holothurian "respiratory-tree" as to four visible and measurable symptoms: external form, inner microscopic anatomy, a barely recognizable function-remnant and pulsatile behavior of a special sort. These items could be analyzed more at length with profit, but such elaboration is not necessary for a conclusion. "Stars" and "cucumbers" are unquestionably progeny of a one-time mutual parent which breathed by means of an intestinal diverticulum; such ancestor throve so long before the Cambrian period that it already had descendants, before that period began, as divergent as these cousins *n*-times removed; and one does not venture to guess how many ages or generations were used up in establishing that early divergence. As having some bearing on the point we may reflect that not much change in either line has taken place in the two hundred million years of which we have some knowledge.

The alert watch for anatomical and physiological change, with the possible birth of new species through mutation, has occupied the spotlight center on the stage of biological research, estimate and reflection for the last thirty years. This search has been so dominant in laboratory and literature that the phenomena of permanence have all but escaped attention, assuredly have elicited little expressed wonder. Constancy, reliability —these are so normal to nature's procedure as to be practically overlooked; nevertheless, this tenacity, this insistence, this never-lapsing memory of nature as heredity weaves its patterns repeatedly through millenniums of time is indescribably impressive even when any normal organ of everyday use is considered; and yet more so when an apparently valueless structure is incorporated in each of hundreds of millions of generations through successive geologic ages. This is one of the numerous biological phenomena which give us pause and induces the quiet, reflective mood; the inheritance carriers are incalculably stable in their effects so long as they themselves are not modified in any manner and can have their way.

Nature's plasticity gives hope; her constancy, dependability and tenacity, when recognized and assimilated, contribute to confidence and equilibrium of spirit; and a consciousness of both is vital to what we call intellectual and spiritual poise in living. Evolution has occurred in consequence of organic modifiability, and as a process is so far accepted in the premises of all the thinking of men that nature's continual adjustments seem a part of simple normality; in regrettable contrast, her uniformity and steadiness are so commonplace and primary as to become almost lost to our awareness. Indeed, it takes a poet to express as well as to be cognizant of this truth; and Lucretius it was who, nearly nineteen hundred years ago, sensed it clearly and proclaimed it in these words:

> Things throughout proceed
> In firm and devious order, and maintain
> To Nature true their fixt generic stamp.

—*Photograph by Bachrach*

PROFESSOR EDWIN G. CONKLIN

THE PROGRESS OF SCIENCE

PROFESSOR EDWIN G. CONKLIN, PRESIDENT OF THE AMERICAN ASSOCIATION

THE biologists of the country were greatly honored and the American Association for the Advancement of Science well served by the election of Dr. Edwin G. Conklin, of Princeton University, to the presidency of the association. He brings to the office a ripe experience in scientific organizations, a wide personal acquaintance among scientists of all kinds and a seasoned judgment of men and affairs. In addition to his high scientific achievements, Professor Conklin is one of our most able and pleasing public speakers and should be able to advance greatly the purpose of the association to bring its work authoritatively and convincingly before the public.

Since its beginning, Dr. Conklin has been active and influential in the management of that unique institution, the Marine Biological Laboratory at Woods Hole. More recently he has, as president of the board of trustees, been able to secure the permanent and effective organization of the Bermuda Biological Station, an international undertaking. As chairman of the committee on grants of the American Philosophical Society and as one of its vice-presidents, he does much to further the work of this ancient and honorable institution.

Among other important connections, Dr. Conklin is one of the original members of the advisory board of the Wistar Institute, and a trustee of the Woods Hole Oceanographic Institute. At one time or another he has been president of each of the various biological organizations to which he belongs. In every instance, Professor Conklin brings a devotion and a competency which greatly profit the affairs of the scientific group which he serves.

In the matter of scientific publication he has been connected with the *Journal of Morphology*, *Journal of Experimental Zoology*, *Genetics* and the *Biological Bulletin*, and was chairman of a committee of the National Academy appointed to study the general question of publications devoted to biological research.

Professor Conklin's own investigations have centered about problems of development, differentiation and phylogeny. In the course of these he has made extensive studies in the embryology of Gasteropods, Tunicates, Coelenterates, Brachiopods and Amphioxus. The study of development led naturally to inquiries into the mechanism of cell reproduction and growth and eventually into the relations between members of a genetic series. He has always been concerned with the philosophical implications of biological studies and has participated actively in public discussion of evolutionary theories. Particularly has he been concerned with the implications of biological facts and theories in human affairs. While Professor Conklin's studies have ranged rather widely, they are always characterized by great care, precision and judgment. Others of his contemporaries have published more papers, but there are few who have contributed more sound and enduring pages to biological literature. The qualities of mind and character which mark his scientific work will certainly be reflected to advantage in his conduct of the affairs of the American Association for the Advancement of Science.

C. E. MCCLUNG

ROBERT S. BROOKINGS HALL, THE ADMINISTRATION BUILDING OF WASHINGTON UNIVERSITY

THE AMERICAN ASSOCIATION AT ST. LOUIS

St. Louis in some mysterious way seems to furnish just the proper background for meetings of unusual importance from the point of view of scientific progress. At the association's first meeting in that city, held in August, 1878, Thomas Alva Edison read a paper on the use of the tasimeter for measuring the heat of the stars and the sun's corona, and another on the sonorous or bubble voltameter, and Albert A. Michelson described his experimental determination of the velocity of light. Five important papers on entomological subjects were read by Charles V. Riley, and a description of a human skull recently discovered in a gravel bed in Colorado was contributed by Thomas Belt of London, well known for his description of the animals and plants of Nicaragua.

These important papers were read while an epidemic of yellow fever was raging in the country to the southward and threatening at any time to reach St. Louis. That dread disease is now only a memory in the United States. Its elimination was made possible by the combined work of physicians, engineers and entomologists, aided by vast improvement in communications. Riley and Edison and others present at the first meeting both directly and through the stimulus of their work and its effect on others played an important part in making St. Louis the healthful and delightful city that it is to-day.

No less important than these early contributions were many that were made at the recent meeting. At present we are unable clearly to foresee their full significance. We feel that progress has been made—indeed, we know it has. But it takes time to allocate these new discoveries and deductions and properly to appraise them in the light of related facts and inferences, some still to be worked out. As an illustration, three papers on certain relations between synthetic growth substances and plants by Drs. P. W. Zimmerman and A. E. Hitchcock were especially outstanding. Their implications are far-reaching. These papers were awarded the association's $1,000 prize. But a number of other papers were almost equally outstanding. Seldom at any meeting have there been so many papers that gave promise of great things to come.

The papers and addresses of the regular program were supplemented by radio talks by some of the nation's leading scientific men. Three of these reached a nation-wide audience over the National Broadcasting Company and Columbia networks, while others were given from stations WEW, KSD, WTMV and KWK. By means of the radio many thousands of people unable to attend the meeting were made aware of the onward march of science.

Radio talks and papers were not the only features of the meeting. The exhibit was unusually extensive and attractive, covering in more or less detail nearly every line of science, pure and applied, and including scientific apparatus and the latest and most authoritative books. No less than seventy-one exhibits were listed in the program. While naturally each exhibit had its own appeal for a special group, most of the exhibits were of interest to all, regardless of their personal preferences. Most attractive to the general public was the exhibit prepared by the Federal Bureau of Investigation of the United States Department of Justice, in which was shown the application of science in many different forms to the tracking down of criminals and the establishment of guilt.

No matter how diversified the program or how efficient the planning of a meeting, there is always something lacking unless the setting is harmonious. In St. Louis those from other cities in attendance were made to feel that they were

THE MUNICIPAL AUDITORIUM IN ST. LOUIS

REGISTRATION HEADQUARTERS AND THE SCIENCE EXHIBITION WERE LOCATED IN THIS BUILDING.

in a thoroughly sympathetic atmosphere. The people of St. Louis proved to be most delightful hosts, and their hospitality went a long way toward making the meeting one of the most pleasant, as it was one of the most profitable, in the history of the association. The association left St. Louis with the hope that it will not be very many years before they again will have the pleasure of foregathering in that congenial city.

The association and its affiliated and associated societies appreciate the aid given in making this St. Louis meeting a success. Especial thanks are due to Washington University, St. Louis University, the Academy of Sciences of St. Louis, the Board of Estimate and Apportionment of the City of St. Louis and the Municipal Auditorium Commission of the City of St. Louis. Special thanks are due to the members of the local committee, who handled so efficiently the numerous and arduous tasks involved in making the preparations for so large a meeting, and to the many laboratories and commercial organizations for the excellent exhibits that assured the success of the Science Exhibition.

AUSTIN H. CLARK

RECENT WORK ON COSMIC RAYS

DR. ARTHUR H. COMPTON, of the University of Chicago, who shared the Nobel prize in 1927, summarized recent work on cosmic rays carried out in his own and in other laboratories before a joint session at St. Louis of the section of physics of the American Association for the Advancement of Science, the American Physical Society and the American Association of Physics Teachers.

Dr. Compton stated that cosmic rays are truly "cosmic" in that they probably emanate from remote galaxies or remote space. The primary cosmic rays, particles as distinct from secondary rays or the disintegration products caused when the rays strike earth's atmosphere, have energies ranging from two billion electron-volts to sixty billion electron-volts, and in occasional bursts, particles occur with energies as high as six hundred billion electron-volts. Their total heat at earth, however, is probably no greater than that of starlight.

A provisional analysis of the components of the rays furnished adequate evi-

dence that the primary cosmic rays are in fact electrically charged particles. The most prominent part of the primary cosmic rays observed above sea-level consists of nearly equal parts of positive and negative electrons. At sea level and below is a very penetrating component for which the identification as protons seems to be required. At very high altitudes there appears a relatively absorbable component, which seems to consist of alpha particles.

The conclusion that cosmic rays are largely electrically charged particles is based chiefly on the "latitude effect" observed in cosmic rays studies. Observations taken throughout the world, among them records of intensity taken at more than 100 stations by some eighty investigators working under the direction of Dr. Compton in 1931–34, show that the rays are affected by the earth's magnetic field. At ordinary altitudes the rays are some 16 per cent. more intense near the magnetic poles than they are near the magnetic equator. At higher altitudes, where the intensity is greater, the ratio of intensities between the poles and the equator is probably more than 100 to 1. Photons, or true rays, would not be so deflected by the earth's magnetic field.

Curve lines of equal cosmic ray intensity follow closely the parallels of geomagnetic latitude, and follow also the lines of frequency of occurrence of auroral displays, which means that the aurora and the cosmic rays are affected by the earth's magnetism in the same manner. The lower intensity of equatorial cosmic rays in the eastern hemisphere than in the western hemisphere corresponds to the stronger magnetic field of the earth in the east.

Dr. Compton showed a new world-map showing "isocosms" or curves of uniform cosmic ray intensities. More exhaustive analysis of this and other data led to the tentative identification of cosmic ray components through a procedure described as "using the earth as a huge though crude magnetic spectrograph"; the earth itself acts as the magnet and in place of the electric field we have the stopping power of the earth's atmosphere.

The conclusion that the rays originate far outside the earth, the sun or the Milky Way is based on the fact that they apparently approach the earth uniformly from all directions. Dr. Compton stated that outside the earth's atmosphere we fail to find any isotropic distribution of matter within our galaxy where such rays might originate. The extra-galactic nebulae, or space itself, would, on the other hand, satisfy the condition of spherical symmetry. He suggested that most of them originate at an effective distance of between one billion and ten billion light years.

There appears to be an effect on the observed intensity of cosmic rays due to the rotation of the Milky Way. According to astronomers this rotation carries us toward about 47 degrees north and right ascension 20 hr. 55 min. at a speed of about 300 kilometers a second. This should cause a diurnal variation in cosmic ray intensity, following sidereal time, through a range of the order of about 0.1 per cent. Apparently there is such a variation.

Efforts to learn how cosmic rays are produced have been unsuccessful. Among the more plausible theories are Lemaître's that they are "super-radioactive particles" emitted at the initial explosion of the expanding universe; Swann's that they are electrons accelerated by electromagnetic induction from the changing magnetic field of "sunspots" on giant stars, and Milne's that they owe their energies to the gravitational attraction of the universe.

In conclusion Dr. Compton pointed out that cosmic rays should prove an extremely useful tool. The immense individual energies of these rays, some of them with an erg of energy for a single atomic projectile, give them a unique

place in the physicist's atomic artillery. Already they have been used in the discovery of positrons. They will be used to extend knowledge of the earth's magnetic field high above the atmosphere; to test electrodynamics in an energy region heretofore inaccessible; and in astronomy, as a powerful means of studying the rotation of the galaxy and of learning the ancient history of the universe. In biology, it is not impossible that they play an important part in the spontaneous variations upon which evolutionary changes depend.

One perplexing recent problem is that the high-energy cosmic ray particles do not excite as much radiation as is required by present electrical theory. An extension of the present theory of electrodynamics is needed, comparable with the extension of Maxwell's electrodynamics introduced by Lorentz and Einstein for the condition of high velocities.

CORRESPONDENT

THE AWARD OF THE PENROSE MEDAL TO PROFESSOR DALY

AT the annual meeting of the Geological Society of America, held at the Waldorf-Astoria, New York, on December 26, 27 and 28, the eighth presentation of the Penrose Medal was made to Professor Reginald Aldworth Daly, Sturgis-Hooper professor of geology at Harvard University. This medal, which was established on March 4, 1927, by the late Richard Alexander Fullerton Penrose, Jr., is awarded, under the terms of the deed of gift, "in recognition of eminent research in pure geology" and "of outstanding original contributions or achievements which mark a decided advance in the science of geology." Former recipients of the medal are Thomas Chrowder Chamberlin, 1927; Jakob Johannes Sederholm, 1928; Francois Alfred Antoine Lacroix, 1930; William Morris Davis, 1931; Edward Oscar Ulrich, 1932; Waldemar Lindgren, 1933; Charles Schuchert, 1934.

Professor Daly is a Canadian by birth, having been born at Napanee, Ontario, on May 19, 1871. He received his A.B. at Victoria University, Toronto, in 1891, and then went to Harvard, where he received the A.M. degree in 1893 and Ph.D. in 1896. He then studied at Heidelberg and Paris. From 1901 to 1907 he was with the Geological Survey of Canada, and in 1907 became professor of physical geology at the Massachusetts Institute of Technology, which position he held until 1912, when he became Sturgis-Hooper professor of geology at Harvard. He has been honored with the doctor of science degree from the University of Toronto and with the Hayden Medal of the Philadelphia Academy of Natural Sciences. In 1932 he was president of the Geological Society of America.

"Although Daly is generally thought of as primarily a petrologist, he has, in fact, made many brilliant contributions in the most widely separated fields of geology," said the committee of award. "His writings now exceed a hundred titles, and indicate clearly the remarkably wide range of his interests. Gifted, too, with an extraordinarily fertile scientific imagination, he has, nevertheless, at no time hesitated to do detailed work of the most painstaking kind. This capacity made itself apparent in one of his earliest writings, 'On the optical characters of the vertical zone of amphiboles and pyroxenes; and on a new method of determining the extinction angles of these minerals by means of cleavage pieces.' It is most conspicuously shown in his work in obtaining the average composition of the various igneous rocks, 1,935 of them, which involved a world-wide scrutiny of the literature, assembling of the analyses, and averaging them. Merely the assembling of 547 analyses of granites from the world's literature, let alone averaging them, be-

PROFESSOR REGINALD ALDWORTH DALY

speaks an extraordinary capacity for hard work.

"Professor Daly's contributions in the field of igneous geology and petrology are too well known to need repetition; in these fields, he is an acknowledged world leader. Many of his ideas have become parts of the body of our science. . . . In addition he has made great and stimulating contributions to physiography, geophysics, volcanology, seismology, coral reef problems and glacial geology."

The presentation was made by Professor Nevin M. Fenneman, head of the department of geology at the University of Cincinnati and retiring president of the Geological Society of America, at the banquet held in connection with the forty-eighth annual meeting of the society.

CHARLES P. BERKEY

PROFESSOR HANS SPEMANN, NOBEL LAUREATE IN PHYSIOLOGY AND MEDICINE

ON October 24 last the Nobel Prize in Physiology and Medicine for 1935 was awarded to Hans Spemann, professor of zoology and director of the Zoological Institute of the University of Freiburg, Germany. He was born in Stuttgart in

1869, the son of the publisher, Wilhelm Spemann. He attended the elementary school in Stuttgart and the Eberhard-Ludwigs Gymnasium, where he took the course in humanistic studies. For one year, 1888–89, he was in business with his father, the following year was spent in military service, and in 1890–91 he was in business in a publishing house in Hamburg. There he decided to enter upon the study of natural science and in the autumn of 1891 he matriculated as a student of medicine at the University of Heidelberg, where he spent four semesters, studying under Gegenbaur, Kühne, Quincke, V. Meyer, Bütschli, Kraaft and Klaatsch. In 1893 he entered the University of Munich as a candidate in medicine and in 1894 he migrated to the University of Würzburg, where he came under the instruction of Sachs, Röntgen and Boveri. He had by this time decided to concentrate on zoology, and he completed, in 1895, his doctoral thesis for the Ph.D. degree under Boveri on the "Development of Strongylus Paradoxus," a beautiful study of the cell-lineage of this nematode worm.

He was assistant in the Zoological Institute at Würzburg from 1895–97, when he was called to Rostock as successor of O. Seeliger. In 1914 he was made director of the Kaiser Wilhelm Institute for Biology at Berlin-Dahlem, where he remained until 1919, when he was called to the University of Freiburg as successor of Franz Doflein, who had succeeded August Weismann as director of the Zoological Institute there. Under Spemann's directorship this institute has become a Mecca for students of experimental embryology, who have flocked to Freiburg from all quarters of the world to come under his instruction and inspiration.

Since his doctoral thesis his researches and those of his students have been largely in the field of the analysis of the development of various amphibians. To this experimental work he has brought extraordinarily delicate and ingenious technique, and unusual ability in devising experiments and interpreting results. Among his earlier experiments, which were especially fruitful in exploring the causes of development, were an extensive series on the causes of development of the lens in the vertebrate eye. It is well known that where the optic cup, which is formed from the embryonic forebrain, comes into contact with the epidermis a thickening and invagination of the latter occurs which gives rise to the lens. Spemann, as well as others, found that the optic cup is able to induce lens formation in the epidermis transplanted from distant parts of the embryo. In *Rana fusca* epidermis from the belly or other regions will form a lens if transplanted over the optic cup, but the epidermis which would form lens in the normal position will not do so in the absence of the cup. In another species, *Rana esculanta*, only normal lens epidermis can form lens, and it will do this even in the absence of the optic cup. In the toad, *Bombinator pachypus*, epidermis from any part of the head region, if transplanted over the optic cup, will form lens, but not that from the belly, while the normal lens epidermis may form a lens in the absence of the cup. In this last case there is "double assurance" that a lens will be formed, since it can be induced by the cup and can also form from lens epidermis without the influence of the cup. These studies demonstrated that while in certain cells there is an intrinsic cause of differentiation there are other cells or parts which lead or "induce" differentiation.

These discoveries threw light upon a question which was foremost in embryology at the time Spemann began his researches, namely, whether the causes of embryonic differentiation are chiefly intrinsic or extrinsic. Roux's experiments on frogs' eggs had led him to

PROFESSOR HANS SPEMANN

emphasize the former, Driesch and O. Hertwig championed the latter. In 1900 Spemann began that long series of experiments on the eggs of amphibians, upon which his scientific reputation largely rests. By means of loops of fine hair he constricted or cut in two in various planes the eggs and early embryos of newts and then followed the development of these moieties for the purpose of determining (1) the developmental capacity (prospective potency) of different cells or regions, (2) the stage at which determination of organs occurs, (3) the position of the virtual embryo in the early egg and its relation to the plane of the first cleavage.

In all stages up to the early gastrula a whole embryo of half-size usually develops from each half of an egg, if the constriction is in the median plane, but if it separates a dorsal from a ventral half the former only gives rise to a typical embryo, the ventral half lacking central nervous system, notochord and dorsal musculature. If constriction occurs after the early gastrula stage only defective embryos result, showing that determination of embryonic parts is already fixed. There was thus shown to be a transition period between the early and late gastrula in which "labile determination" becomes "final." In the early gastrula the localization of organs is not

irrevocably determined, as was proved by exchanging transplants of presumptive neural plate and presumptive epidermis, when the former becomes ordinary epidermis and the latter neural plate. But when a portion of the dorsal lip of the gastrula is transplanted to another region it does not follow the development of neighboring parts but forces neighboring parts to follow it. "It organizes its new surroundings and gives origin to a secondary embryo." Hence the region of the dorsal lip of the gastrula was called the "center of organization" and its cells or materials "organizers." More detailed experiments showed that there are "head organizers" and "trunk organizers," which occupy specific positions in the dorsal lip. These organizers evidently act as the optic cup does in inducing alien epidermis to form a lens, and Spemann has suggested that they might better be called "inductors" rather than "organizers," especially since it has been found that dead cells and dried and crushed material from the dorsal lip will induce embryo formation wherever they are implanted. Work on the nature of the "organizer" or "inductor" is going on in many laboratories and it is too early to express a definite opinion on this subject, but to have found that there is a definite region of the embryo which leads in differentiation is a major discovery and it was specifically for this that the Nobel award was made. Spemann poses the question whether the whole course of development is a series of inductions of one part after another in the nature of a "chain reaction." If so, it is purely epigenetic, but on the other hand phenomena of "double assurance" seem to speak against so simple a process.

Spemann is not a hard-boiled mechanist; he offers no absurdly simple explanations of one of the most complex phenomena in all nature. On the contrary, he recognizes the profound and perplexing nature of embryonic development. In his rectorial address at the University of Freiburg in 1923 he said: "Nature acts in development as an artist making a picture or model, indeed as every organizer does who handles materials whether living or not living. . . . This differs from Weismann's purely mechanistic theories and resembles our own activities." And in an address at the Marine Biological Laboratory in Woods Hole in 1931 he closed by saying: "It is my personal conviction that the processes going on in the living matter may be compared with nothing else so well as with the workings of our own mind. To deal with the living organism as if it were animated unto its last fibers seems to me the best way to understand it."

The fundamental character of Spemann's researches has been widely recognized. He was chosen rector of the University of Freiburg in 1923, was Croonian lecturer before the Royal Society of London in 1927, and Silliman lecturer at Yale University in 1933. He is a member of many scientific and learned societies in Europe and is a foreign associate of our own National Academy of Sciences. His modest, sincere and kindly nature have endeared him to a multitude of friends who rejoice in this latest and greatest honor which has been conferred upon him.

EDWIN G. CONKLIN